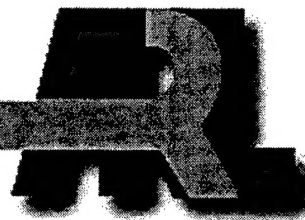


ARMY RESEARCH LABORATORY



Initial Evaluation of the CTA International 40-mm Cased Telescoped Weapon System

Timothy G. Farrand

ARL-TR-2275

AUGUST 2000

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Abstract

The capability of off-the-shelf medium caliber ammunition has been advertised extensively. As the decision about the main armament for imminent medium caliber platforms approaches, more definitive independent analyses of the advertised systems are being conducted. To increase the current database, an evaluation of the 40-mm cased telescoped weapon system (CTWS) was coordinated between the U.S. Government and CTA International (CTAI), a French-United Kingdom company. The emphasis of this evaluation was the performance of the armor-piercing, fin-stabilized, discarding sabot (APFSDS) projectile. In addition, the pressures inside the Bradley fighting vehicle, where the CTWS was mounted, and shock measurements on the exterior of the vehicle were taken to estimate the effect of the weapon system on the vehicle and the crew. The evaluation of the terminal effects of the APFSDS against selected Senior National Representatives (SNR)-defined range targets is documented in a separate, classified version of the evaluation.

The APFSDS ammunition performed as advertised, with a muzzle velocity of approximately 1640 m/s and a velocity decay of 0.12 m/s/m. These values give the 40-mm CTAI APFSDS a high velocity at the target for typical engagement distances. The measured shock to the vehicle and overpressures within the vehicle during firing all appear to be at acceptable levels for these initial tests.

ACKNOWLEDGMENTS

The author would like to thank the Project Manager-Tank and Medium Caliber Armament Systems (PM-TMAS) for funding this program and coordinating the efforts with CTA International (CTAI). He would also like to thank the representatives from CTAI, primarily Mr. Mike Duckworth, Mr. Richard Braddock, and Mr. David Leslie. The CTAI crew that supported the effort also performed a magnificent job of preparing the gun for operation, mounting it in the Bradley fighting vehicle, and training the Aberdeen Test Center (ATC) staff for the demonstration; the crew's efforts are very commendable. Finally, the author would like to extend his sincere acknowledgments to the crew at ATC. They performed an excellent job of completing the CTAI evaluation and demonstrating the ammunition. Ms. Hazel Cassady and Mr. Joe Zelik, the test directors at ATC, did an outstanding job of organizing the effort and having the program performed without any problems.

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INITIAL EVALUATION OF THE CTA INTERNATIONAL 40-MM CASED TELESCOPED WEAPON SYSTEM

1. Introduction

1.1 Overview

The capability of off-the-shelf medium caliber ammunition has been advertised extensively. As the decision about the main armament for imminent medium caliber platforms approaches, more definitive independent analyses of the advertised systems are being conducted, based on available data. To increase the database, the evaluation of the 40-mm cased telescoped weapon system (CTWS) was coordinated between the U.S. Government and CTA International (CTAI), a French-United Kingdom (UK) company. The emphasis of this evaluation was the armor-piercing, fin-stabilized, discarding sabot (APFSDS) projectile. This evaluation is similar to one conducted for the 35-mm Rheinmetall APFSDS (October 1998) in a similar cooperative program. The evaluation culminated in a one-day demonstration to present to the users, namely, the U.S. Army Infantry Center, U.S. Army Armor Center, U.S. Marines, and other Government organizations, that is, the Office of the Secretary of Defense, Tank-Automotive Command (TACOM), Armament Research, Development, and Engineering Center (ARDEC), Army Materiel Systems Analysis Activity, Army Evaluation Center, various project managers, etc., the capability of the 40-mm CTAI ammunition against current threats.

The Program Manager for the Tank and Medium Caliber Armament Systems (PM-TMAS) sponsored the evaluation. The U.S. Army Research Laboratory (ARL) and the Aberdeen Test Center (ATC) at Aberdeen Proving Ground (APG), Maryland, performed the evaluation in October through November 1999, with the actual demonstration on 3 November.

The program was divided into two evaluations; the first evaluation characterized the APFSDS ammunition performance against Senior National Representatives (SNR)-defined range targets, and the second evaluation investigated the integration of the CTWS in the Bradley fighting vehicle (BFV). Because of the release restrictions and classification of the data from the two evaluations, the documentation will also be separated into two reports. This unclassified report addresses the details of the system characteristics. A separate, classified report will address the terminal ballistic characterization of the APFSDS.

1.2 Background

Mr. Mike Duckworth, a representative from CTAI, supplied the following background information about the CTA system and the CTAI Company.

Program History

The CTWS development program, which began in 1997, was preceded by a technology phase, which lasted 3 years. This initial program phase was conducted in conjunction with the UK Defence Evaluation and Research Agency (DERA) and the French agency SPART (*Service des Programmes d'Armement Terrestre*). This technology work was conducted in 45-mm caliber initially (following the U.S., UK, and French agreed-upon 45-mm CTA standard North Atlantic Treaty Organization [NATO] agreement [STANAG]); it changed in 1997 to 40 mm. At the end of this phase, DERA reported CTA technology as low risk. CTAI is now in the fourth year of its full development program, which is due to be completed in early 2002.

Scope of Program

From the beginning, the product that is being developed is a complete weapon system. The design activities conducted at CTAI's facilities cover the weapon, ammunition-handling system, and ammunition, including APFSDS, general purpose (GP) rounds, and target practice-tracer rounds. The scope and tasks defined within the CTWS development program are closely aligned with the UK Tactical Reconnaissance Armored Combat Equipment Requirement (TRACER) and with the U.S. Future Scout and Cavalry System (FSCS) program definition.

System Description

Weapon

The weapon weighs 218 kg, and its compact size (by virtue of the unique rotating chamber functionality) gives it a swept volume of only 74 liters for an arc of -10 degrees to +35 degrees. A photograph of the gun is shown in Figure 1.



Figure 1. 40-mm CTWS Weapon.

The simple cylindrical shape of the CTA cartridge simplifies the cannon by virtue of the "push-through principle" of operation; its compactness and modularity foster elegant integration solutions. The principle of the weapon function is shown by the graphic in Figure 2.

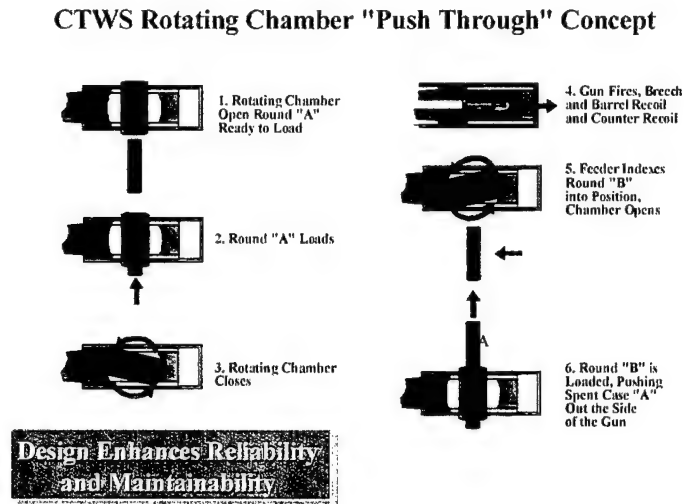


Figure 2. "Push-Through" Principle of 40-mm CTWS Weapon.

As demonstrated in this evaluation, the CTWS gun is compact enough to be installed in an existing BFV (see Figure 3).



Figure 3. 40-mm CTWS Integrated in BFV Turret.

Additionally, computer-aided design (CAD) analysis has been employed to demonstrate how the entire CTWS, feed system, and ammunition storage can be integrated into the current BFV. A complete 105-round mission load, linkless feed system has been produced and demonstrated by CTAI during mock-up conditions. This feed system fits in the same area within the BFV that is occupied by the current 25-mm Bushmaster weapon system. This is shown in Figure 4.

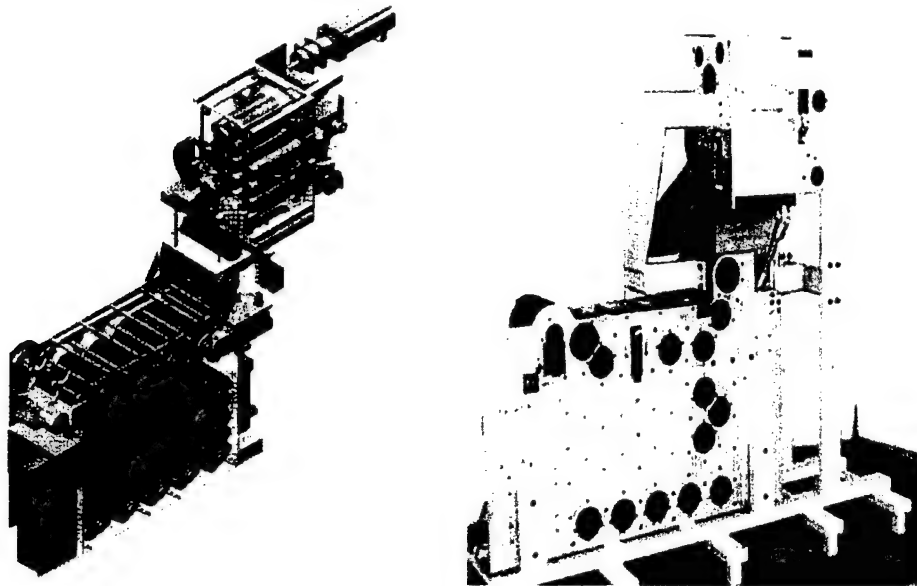


Figure 4. 105-round Linkless Feeder for BFV.

Projectile Characteristics

The APFSDS round currently being developed follows the conventional cased telescopic ammunition (CTA) concept in which the projectile is positioned inside the cylindrical cartridge case and inside the propellant. This is shown in Figure 5. The resulting 40-mm CTA round is half the length of a conventional 40-mm cartridge manufactured by Bofors Precision Machining, Inc. The projectile follows the classic concept in many ways, as it consists of a tungsten alloy penetrator, an aluminum sabot, and a slipping obturator. The penetrator is maintained in a stable flight by a steel fin fixed to the rear. A tracer has been added inside the fin unit. The penetrator core is a classic tungsten alloy monoblock cylinder, as seen in Figure 6.

Front

Rear

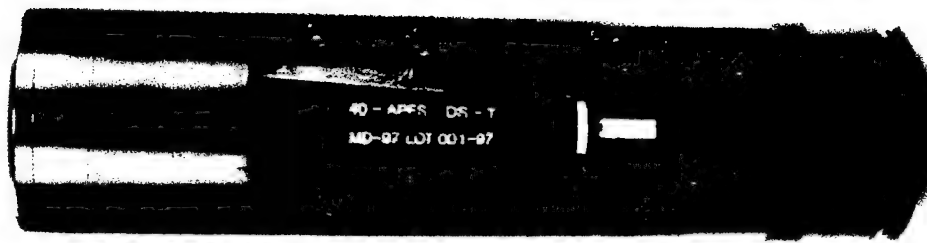


Figure 5. 40-mm CTWS APFSDS Cartridge in Section.



Figure 6. 40-mm CTWS APFSDS Penetrator.

The penetrator is threaded along a significant length of the penetrator to provide the driving interface with the aluminum sabot, and a smaller finer thread is added at the rear to attach a stabilizing fin unit. The APFSDS propellant is a standard single base loose grain propellant charge (BTU7). The propellant is NATO qualified and already in service in a number of European medium caliber weapon systems. The sabot is a "pull" sabot rather than the more conventional "push" saddle-type sabot as used in conventional APFSDS ammunition. Apart from this difference, the technology can be considered standard engineering. The sabot design has been optimized to provide the maximum amount of stability to the projectile inside the gun barrel, while keeping its mass to a minimum. The fin unit is a classic four-bladed steel fin. A small conventional tracer canister is screwed into the rear of the fin unit. Obturation is obtained by a Nylon slipping-driving band assembled over the sabot.

Table 1 lists the physical parameters of the CTAI APFSDS. Also shown are the advertised muzzle velocity and velocity decay.

Table 1
The Physical Parameters of the CTAI APFSDS Projectile

| Projectile | | Penetrator | |
|-------------------------|------|------------------------------|------|
| Mass (g) | 440 | Mass (g) | 250 |
| Length (mm) | 219 | Effective length (mm) | 165 |
| Caliber (mm) | 40 | Diameter (mm) | 10.3 |
| Muzzle velocity (m/s) | 1600 | Density (g/cm ³) | 17.5 |
| Velocity decay (m/s/km) | 120 | | |

2. Purpose

As mentioned in Section 1.2, the CTA 40-mm gun system is a prime candidate for future medium caliber platforms (U.S. FSCS-UK TRACER) and possibly any revisions of existing systems, e.g., BFV. Therefore, the validation of the performance of the gun system is of major concern to many system developers. As part of the demonstration, the CTAI gun was mounted into an "old" BFV, from which the current 25-mm Bushmaster gun and feed system had been removed. (The 35-mm Bushmaster III had previously been mounted in the turret of this BFV for a similar demonstration in October 1998.) The primary ammunition being evaluated here is the APFSDS. To complete the evaluation of lethality at the target, an accurate impact velocity, which is determined by the muzzle velocity and velocity decay, is required. In addition, the pressures inside the vehicle and shock measurements on the vehicle were taken to estimate the effect of firing the CTWS from the BFV on the vehicle and on the crew. These experiments will give initial estimates of how the CTAI gun operates in the BFV and essential information about the APFSDS external characteristics.

3. Procedures

The gun and the BFV were located at the ATC facility Barricade 2. The gun was mounted onto the BFV. As mentioned earlier, CTAI was provided CAD drawings of the BFV's interior before the BFV arrived in the United States. CTAI developed their gun and feed system to fit in the BFV turret. It was installed in the turret, as can be seen in Figure 7.

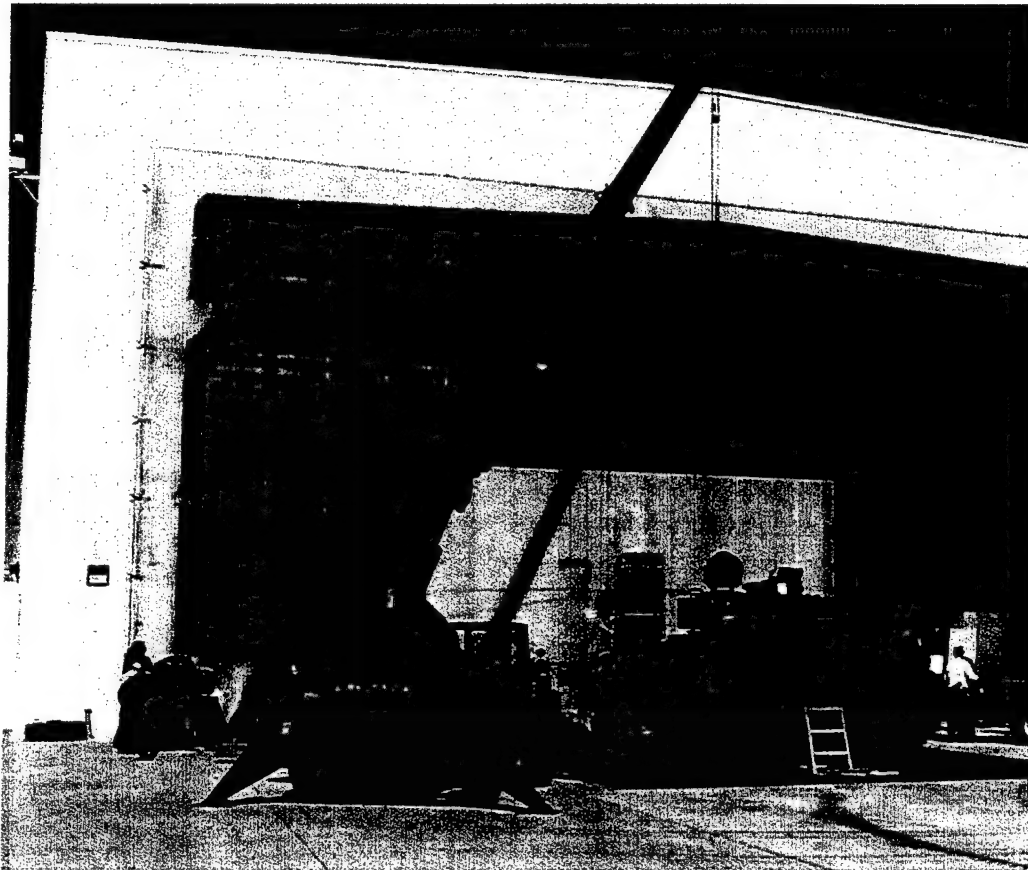


Figure 7. Mounting the CTWS in the BFV.

After the gun was mounted in the BFV turret, numerous practice shots with inert GP rounds (projectiles without high explosives) were fired. The functioning of the gun in the turret was evaluated during this phase. This was done in both single shot mode and in a three-round burst mode. Once it was evident that the gun was functioning properly, the APFSDS rounds were evaluated. These were fired to determine the actual muzzle velocity and velocity at range. The gun was elevated slightly so the velocity could be measured at a considerable range (i.e., farther than 4000 meters). While this was being done, the shock to the vehicle's exterior and the pressure inside the vehicle were measured.

A final series of shots was conducted to examine the yaw cycle at short distances, less than 100 meters. For this last portion, the gun was moved to the ATC facility Barricade 1, because of the better terrain environment.

4. Facility Setup

For all shots, the velocity was measured with a Weibel tracking system, which follows the projectile and determines velocity and deceleration as a function of time. This is converted to velocity at range. Also, high speed photography, located at various positions behind, to the side, and in front of the gun was used to observe the projectile exiting the gun barrel. Blast overpressures were measured inside the vehicle at several locations: in the crew compartment, in the turret, and in the driver area. Shock measurements were made at several locations on the exterior of the vehicle: the gun shield, turret roof, hull rear and hull front. ATC personnel reduced the data for the projectile velocity measurements, the blast overpressures, and the shock measurements (Walton, 2000).

5. Results and Discussion

The incorporation of the 40-mm CTAI gun system into the BFV vehicle was successful. With the assistance of the ATC personnel, the gun was easily installed in the turret, as previously seen in Figure 4. A photograph of the gun mounted in the BFV turret is shown in Figure 8. Figure 9 shows the 40-mm CTAI gun being fired from the BFV mount.

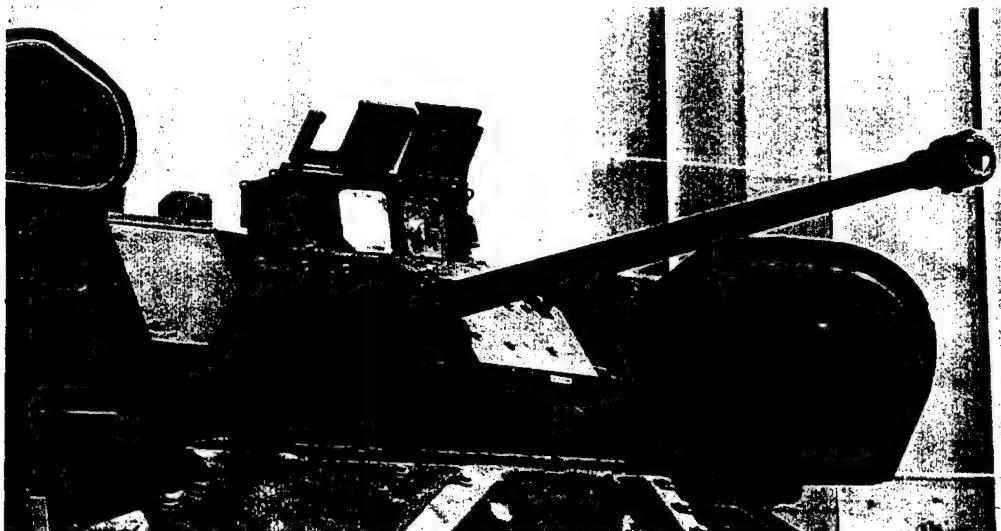


Figure 8. 40-mm CTAI Gun Mounted on the BFV.



Figure 9. 40-mm CTAI Gun System Firing From the BFV.

The sequence of the rounds fired is shown in Table 2 which lists the shot number, the date, the type of round fired (GP - inert or APFSDS), and the shot mode (single shot or burst). Table 3 lists the meteorological conditions for the two days of the investigation.

Table 2
Schedule Results

| Round Number | Date/Time | Round Type | Firing Mode |
|--------------|-----------------|------------|--------------------------|
| 1 | 26 Oct / 16:40 | GP - Inert | Single shot |
| 2 | 26 Oct / 17:18 | GP - Inert | Single shot |
| 3 | 26 Oct / 17:57 | GP - Inert | Single shot |
| 4 | 27 Oct / 10:24 | GP - Inert | Single shot |
| 5 | 27 Oct / 11:08 | APFSDS | Single shot |
| 6 | 27 Oct / 11:43 | APFSDS | Single shot |
| 7 | 27 Oct / 12:18 | APFSDS | Single shot |
| 8 | 27 Oct / 14:32 | APFSDS | Single shot, elevated |
| 9 | 27 Oct / 14:41 | APFSDS | Single shot, elevated |
| 10 | 27 Oct / ~15:00 | APFSDS | Single shot, elevated |
| 11 | 27 Oct / 15:43 | GP - Inert | third burst |
| 12 | 27 Oct / 16:04 | GP - Inert | third burst |

The high speed photography was used to capture the projectiles exiting the muzzle of the gun system. Figure 10 shows the GP round as it exits the muzzle and Figure 11 shows the APFSDS round. The sabot separation can be seen for the APFSDS round.

Table 3
Meteorological Conditions

| Time | Wind Direction Average | SD ^a | Wind Speed Average | Peak (m/s) | Temp (°C) | Dew Point (°C) | Relative humidity (percent) | Pressure (Mbs) | Density (Kg/m ³) |
|-----------------|------------------------------|-----------------|--------------------------|---------------|--------------|----------------------|-----------------------------------|-------------------|---------------------------------|
| 26 October 1999 | | | | | | | | | |
| 07:00 | 256 | 24 | 2.1 | 4.0 | 8.7 | 4.9 | 77 | 1019.5 | 1.2563 |
| 08:00 | 229 | 25 | 2.3 | 5.7 | 10.4 | 5.1 | 70 | 1019.5 | 1.2487 |
| 09:00 | 240 | 23 | 3.0 | 7.0 | 11.0 | 5.2 | 67 | 1019.9 | 1.2461 |
| 10:00 | 236 | 23 | 2.8 | 6.9 | 11.8 | 5.2 | 64 | 1019.6 | 1.2422 |
| 11:00 | 222 | 23 | 2.9 | 5.5 | 13.1 | 6.0 | 62 | 1019.0 | 1.2356 |
| 12:00 | 228 | 24 | 2.9 | 6.2 | 14.4 | 6.8 | 60 | 1017.9 | 1.2285 |
| 13:00 | 231 | 23 | 2.6 | 4.7 | 16.0 | 7.0 | 55 | 1016.7 | 1.2202 |
| 14:00 | 246 | 20 | 3.0 | 5.9 | 16.4 | 6.2 | 51 | 1015.9 | 1.2177 |
| 15:00 | 240 | 21 | 2.6 | 5.2 | 17.0 | 5.9 | 48 | 1015.2 | 1.2149 |
| 27 October 1999 | | | | | | | | | |
| 07:00 | 339 | 10 | 1.9 | 3.2 | 9.2 | 2.1 | 61 | 1019.4 | 1.2543 |
| 08:00 | 340 | 14 | 1.7 | 3.2 | 10.4 | 2.3 | 57 | 1020.2 | 1.2499 |
| 09:00 | 348 | 15 | 2.8 | 6.0 | 12.7 | 2.0 | 48 | 1021.1 | 1.2414 |
| 10:00 | 351 | 14 | 3.8 | 6.7 | 13.4 | 1.7 | 45 | 1021.6 | 1.2386 |
| 11:00 | 1 | 19 | 3.5 | 6.7 | 14.6 | 2.8 | 45 | 1021.8 | 1.2334 |
| 12:00 | 4 | 20 | 3.5 | 7.1 | 15.3 | 2.5 | 42 | 1021.7 | 1.2304 |
| 13:00 | 10 | 21 | 3.4 | 7.3 | 15.6 | 2.4 | 41 | 1021.5 | 1.2289 |
| 14:00 | 358 | 27 | 3.1 | 6.4 | 15.3 | 3.1 | 44 | 1021.4 | 1.2299 |
| 15:00 | 7 | 21 | 3.3 | 7.0 | 15.5 | 3.3 | 44 | 1021.6 | 1.2292 |

^aSD = standard deviation



Figure 10. Photograph of GP Projectile Exiting the Muzzle.



Figure 11. Photograph of APFSDS Projectile Exiting the Muzzle.

A sample of the velocity table is shown in Table 4. The velocity data tables for all the shots are listed in Appendix A. This sample table is for the APFSDS at extended range (~5000 meters).

The muzzle velocity achieved for this shot is 1639 m/s, which is more than advertised by CTAI (1600 m/s). Also shown in the table is the retardation or velocity decay (m/s/m). This retardation starts at 0.127 m/s/m and then drops to below 0.120 m/s/m at ranges greater than 500 meters. This initial high retardation is an indication of the yaw cycle that APFSDS rods experience when exiting the muzzle of the gun. As the penetrator begins its yaw cycle, it has a high yaw and a corresponding high drag (high velocity decay). As the yaw cycle dampens, reducing to nearly zero yaw, the penetrator will have much lower drag (low velocity decay). As can be seen in Table 4, after approximately 500 meters, the velocity decay is just below 0.120 m/s/m, which was the advertised value by CTAI.

The velocity of the inert GP round, although not the primary concern in this evaluation, was measured to be 1035 m/s. The velocity for these rounds was determined as far as approximately 700 meters. At this distance, the velocity had dropped to less than 700 m/s, for an average velocity decay of more than 0.400 m/s/m. For typical air-burst projectiles, the error in burst location greatly affects the projectile's performance. For air-burst projectiles with timed fuzes, the range error is reduced if the projectile is traveling at lower velocities. The large drag on the GP round may increase its probability of bursting at the correct location or may increase its probability of hit.

The data from the velocity measurements were plotted as a function of range for the GP (inert) round in Figure 12. Three of these shots (No. 1, No. 2, and No. 3) were measured from muzzle exit to 700 meters. The last shot (No. 4) was measured only to 400 meters. The fact that these curves lie very close to each other implies that the velocity and drag are very repeatable for these GP (inert) rounds.

Figure 13 shows the velocity as a function of range for the three shots of the APFSDS projectile at distances less than 1000 meters. These three plots show

Table 4
Sample Velocity Measurements

| W E I B E L S C I E N T I F I C W-1000i #5037 | | | | | |
|--|----------|--------------|----------|----------|---------|
| DATE | | TIME | CHANNEL | ROUND | |
| 991027 | | 14:32:06.617 | 1-4 | 8 | |
| B2 CASSIDY 40-MM AP | | | | | |
| <u>VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS</u> | | | | | |
| Velocity Results : Adjusted (based on sliding fits) | | | | | |
| NO | TIME | VELOCITY | DISTANCE | ACCL. | RETARD. |
| | ms | m/s | m | m/s/s | m/s/m |
| Muzz | 0.000 | 1639.096 | 0.00 | -209.588 | 0.1279 |
| 1 | 61.248 | 1626.387 | 100.00 | -205.418 | 0.1263 |
| 2 | 122.972 | 1613.837 | 200.00 | -201.214 | 0.1247 |
| 3 | 185.176 | 1601.453 | 300.00 | -196.979 | 0.1230 |
| 4 | 247.859 | 1589.304 | 400.00 | -192.683 | 0.1212 |
| 5 | 311.020 | 1577.211 | 500.00 | -189.885 | 0.1204 |
| 6 | 374.665 | 1565.279 | 600.00 | -186.963 | 0.1194 |
| 7 | 438.796 | 1553.357 | 700.00 | -184.844 | 0.1190 |
| 8 | 503.420 | 1541.471 | 800.00 | -182.241 | 0.1182 |
| 9 | 568.543 | 1529.679 | 900.00 | -180.140 | 0.1178 |
| 10 | 634.168 | 1517.942 | 1000.00 | -177.947 | 0.1172 |
| 11 | 700.302 | 1506.254 | 1100.00 | -176.168 | 0.1170 |
| 12 | 766.951 | 1494.582 | 1200.00 | -174.677 | 0.1169 |
| 13 | 834.121 | 1482.904 | 1300.00 | -173.472 | 0.1170 |
| 14 | 901.824 | 1471.196 | 1400.00 | -172.540 | 0.1173 |
| 15 | 970.069 | 1459.424 | 1500.00 | -170.984 | 0.1172 |
| 16 | 1038.866 | 1447.692 | 1600.00 | -168.770 | 0.1166 |
| 17 | 1108.221 | 1436.094 | 1700.00 | -166.392 | 0.1159 |
| 18 | 1178.134 | 1424.589 | 1800.00 | -164.829 | 0.1157 |
| 19 | 1248.615 | 1413.057 | 1900.00 | -163.350 | 0.1156 |
| 20 | 1319.676 | 1401.491 | 2000.00 | -162.146 | 0.1157 |
| 21 | 1391.325 | 1389.889 | 2100.00 | -161.352 | 0.1161 |
| 22 | 1463.575 | 1378.310 | 2200.00 | -159.924 | 0.1160 |
| 23 | 1536.435 | 1366.685 | 2300.00 | -159.153 | 0.1165 |
| 24 | 1609.919 | 1355.017 | 2400.00 | -158.387 | 0.1169 |
| 25 | 1684.040 | 1343.315 | 2500.00 | -157.179 | 0.1170 |
| 26 | 1758.810 | 1331.590 | 2600.00 | -156.388 | 0.1174 |
| 27 | 1834.241 | 1319.844 | 2700.00 | -155.610 | 0.1179 |
| 28 | 1910.349 | 1308.030 | 2800.00 | -154.988 | 0.1185 |
| 29 | 1987.150 | 1296.123 | 2900.00 | -154.290 | 0.1190 |
| 30 | 2064.660 | 1284.203 | 3000.00 | -152.954 | 0.1191 |
| 31 | 2142.893 | 1272.291 | 3100.00 | -151.473 | 0.1191 |
| 32 | 2221.861 | 1260.404 | 3200.00 | -150.078 | 0.1191 |
| 33 | 2301.578 | 1248.491 | 3300.00 | -148.724 | 0.1191 |
| 34 | 2382.058 | 1236.575 | 3400.00 | -147.286 | 0.1191 |
| 35 | 2463.318 | 1224.665 | 3500.00 | -145.891 | 0.1191 |
| 36 | 2545.373 | 1212.762 | 3600.00 | -144.316 | 0.1190 |
| 37 | 2628.237 | 1200.860 | 3700.00 | -142.965 | 0.1191 |
| 38 | 2711.925 | 1188.973 | 3800.00 | -141.537 | 0.1190 |
| 39 | 2796.456 | 1177.061 | 3900.00 | -139.973 | 0.1189 |
| 40 | 2881.845 | 1165.189 | 4000.00 | -138.506 | 0.1189 |
| 41 | 2968.109 | 1153.317 | 4100.00 | -137.008 | 0.1188 |
| 42 | 3055.264 | 1141.381 | 4200.00 | -135.838 | 0.1190 |
| 43 | 3143.338 | 1129.486 | 4300.00 | -134.094 | 0.1187 |
| 44 | 3232.340 | 1117.649 | 4400.00 | -132.459 | 0.1185 |
| 45 | 3322.288 | 1105.875 | 4500.00 | -130.748 | 0.1182 |
| 46 | 3413.203 | 1093.962 | 4600.00 | -129.780 | 0.1186 |
| 47 | 3505.112 | 1082.132 | 4700.00 | -128.416 | 0.1187 |
| 48 | 3598.034 | 1070.268 | 4800.00 | -126.631 | 0.1183 |
| 49 | 3691.989 | 1058.456 | 4900.00 | -124.910 | 0.1180 |

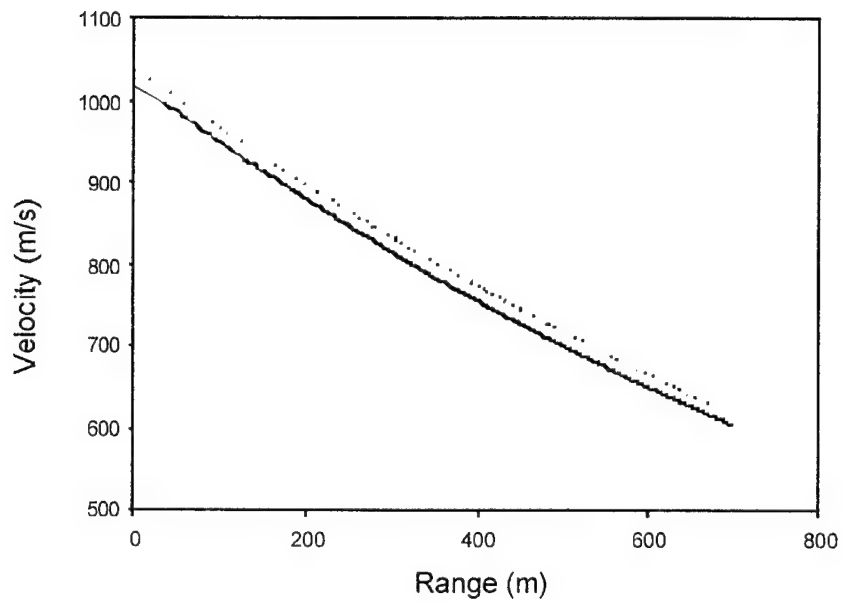


Figure 12. Velocity as a Function of Range for the GP Projectiles.

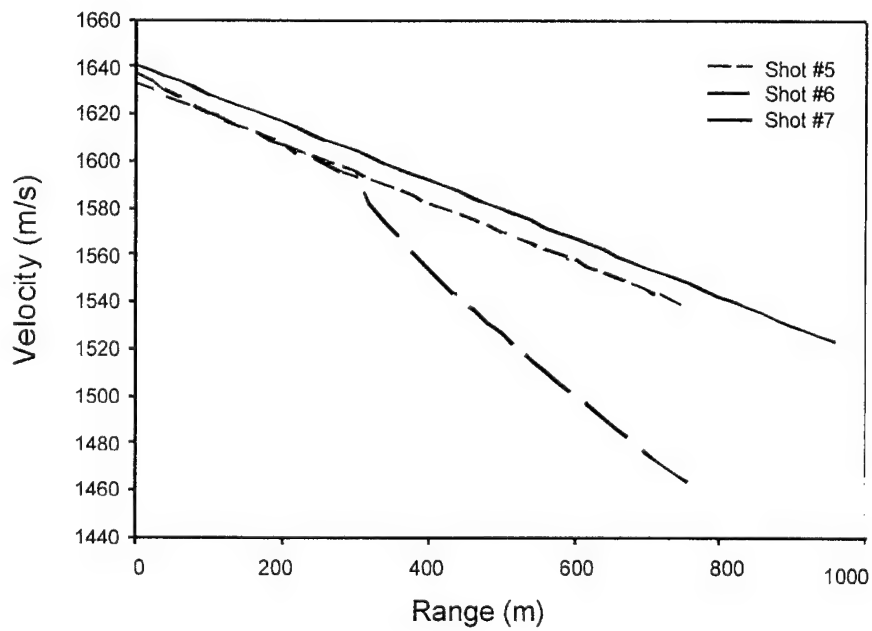


Figure 13. Velocity as a Function of Range for the APFSDS (short range).

approximately the same muzzle velocity (1630 to 1640 m/s) and velocity for about 300 meters. At 300 meters, Shot No. 6 begins to decelerate much faster than the other rounds. Shot No. 6 probably hit a yaw card pole, possibly causing it to lose some of its fins or inducing high yaw. This would definitely make it deviate from its flight line and decelerate much quicker. The velocity as a function of range for extended distances (~6000 meters) is shown in Figure 14, a plot of Shot No. 8 and 9. These extended distances were achieved by elevating the barrel slightly. As can be seen, the velocities of the two rounds track almost identically. The muzzle velocity is about 1640 m/s, and the average deceleration over 5000 meters is 0.12 m/s/m. This is a high muzzle velocity and very respectable velocity decay, which will give high velocity upon impact for typical target engagements, e.g., 1515 m/s at 1000 meters and 1400 m/s at 2000 meters. These high impact velocities at range should enhance terminal effects.

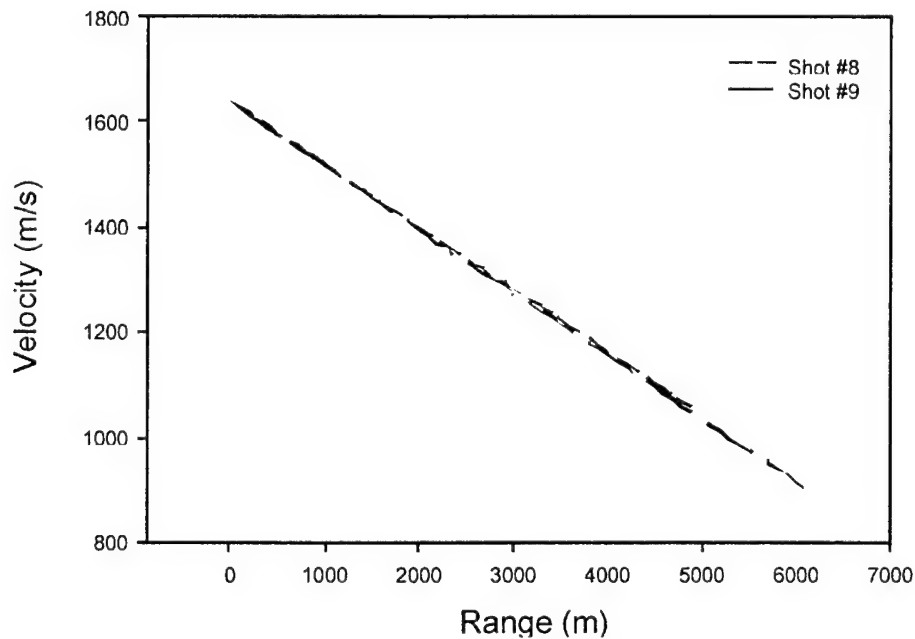


Figure 14. Velocity as a Function of Range for the APFSDS (extended range).

In addition to the velocity at range evaluation, some preliminary shots with the APFSDS projectiles were made with a downloaded propellant charge, to achieve a velocity of 1450 m/s. The yaw cycle and yaw node were determined for these downloaded projectiles. Numerous yaw cards, located from 60 to 100 meters, were used for the yaw cycle determination. For these velocities, the yaw was very repeatable, with a yaw node occurring at approximately 70 meters.

Blast overpressures were measured at four locations: the driver, the turret right, the turret left, and the rear crew compartment. These data were assessed by ATC in accordance with MIL-STD-1474C, Noise Limits for Military Materiel, and were compared to the A- and B-durations and maximum exposures per day for single hearing protection. Table 5 shows the peak pressures recorded and the maximum exposures per day for all the experiments at these locations. A sample plot of the time-pressure data is shown in Figure 15. All the plots of the overpressure for each location and each shot are listed in Appendix B.

Table 5
Measured Pressures and Maximum Allowable Exposures per Day

| Rd No. | Ch 1. Driver | | Ch 2. Turret Left | | Ch 3. Turret Right | | Ch. 4 Rear Crew Area | |
|-----------|---------------------------|-----------------------------|---------------------------|-----------------------------|---------------------------|-----------------------------|---------------------------|-----------------------------|
| | Peak Pressure (kPa) | Max. Exposure Per day | Peak Pressure (kPa) | Max. Exposure Per day | Peak Pressure (kPa) | Max. Exposure Per day | Peak Pressure (kPa) | Max. Exposure Per day |
| 1 | 0.9 | 105631 | 2.4 | 2186 | 2.2 | 2930 | 1.3 | 13647* |
| 2 | 1.0 | 64832 | 2.6 | 2092 | 2.2 | 2802 | 1.4 | 11748* |
| 3 | 0.8 | 79216 | 2.8 | 1592 | 2.3 | 3714 | 1.2 | 17559* |
| 4 | 1.0 | 74701 | 3.0 | 1195 | 2.3 | 3388 | 0.8 | 108578* |
| 5 | 1.7 | 7812 | 2.9 | 1363 | 3.3 | 786 | 0.8 | 80724* |
| 6 | 1.7 | 7710 | 3.3 | 837 | 3.4 | 676 | 1.1 | 23796* |
| 7 | 1.7 | 7236 | 2.7 | 1648 | 3.5 | 632 | 0.9 | 53535* |
| 8 | 1.4 | 10984 | 3.1 | 830 | 3.4 | 1339 | 1.0 | 39039* |
| 9 | 1.6 | 10175 | 3.0 | 1122 | 3.5 | 1254 | 0.9 | 59874* |
| 10 | 1.5 | 11777 | 3.0 | 874 | 3.4 | 1309 | 1.0 | 42837* |
| 11 | 0.9 | 74880 | 3.2 | 2075 | 2.3 | 3591 | 0.9 | 60452* |
| 12 | 1.1 | 35054 | 2.8 | 3376 | 2.2 | 3709 | 0.7 | 151655* |

*Invalid data – a worst case of 200 ms B-duration used in maximum exposures per day calculation

The overpressures are summarized in Table 6, which shows the maximum pressure and corresponding smallest allowable exposures per day (as defined previously), recorded at each location for each firing scenario. The GP rounds had the lowest peak pressures for all locations. Going from a single shot to a burst with the GP rounds increases the peak pressure in most locations. The greatest peak overpressures were recorded for the single shot scenario with the APFSDS (not elevated) at the right turret location (directly behind the gun). The corresponding maximum allowable exposures per day would be 632, at this peak pressure. It is noted by ATC (Walton, 2000) that simply increasing the hearing protection level from the single ear protection to the double ear protection level causes the allowable exposures per day to increase by a factor of 20.

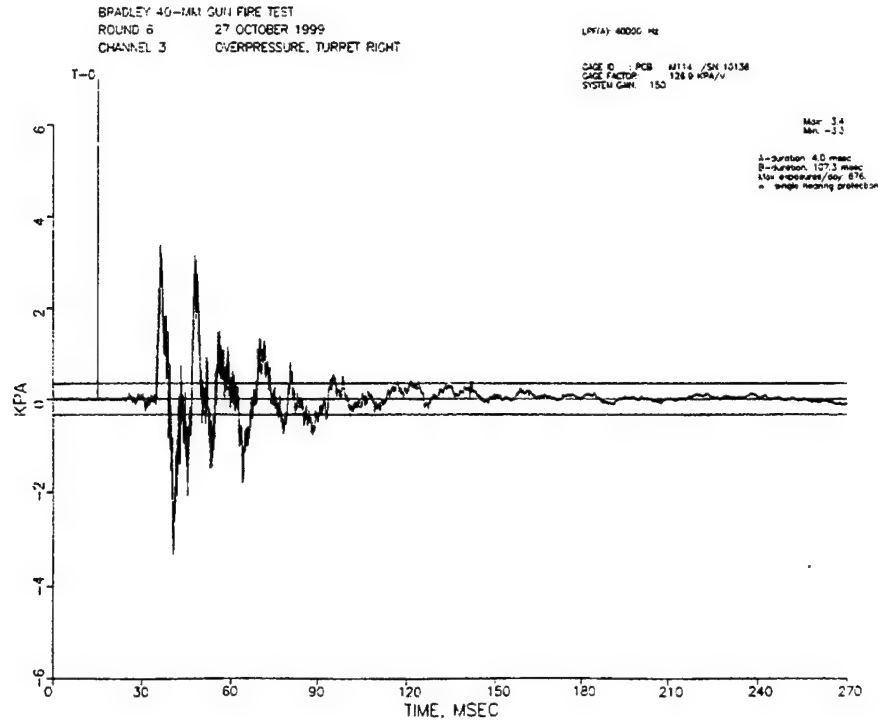


Figure 15. Sample Plot of Measured Overpressures at the Turret Right Location.

Table 6

Maximum Peak Pressures and Maximum Allowable Exposures per Day

| Scenario | Ch 1. Driver | | Ch 2. Turret Left | | Ch 3. Turret Right | | Ch. 4 Rear Crew Area | |
|-------------------|---------------------|-----------------------|---------------------|-----------------------|---------------------|-----------------------|----------------------|-----------------------|
| | Peak Pressure (kPa) | Max, Exposure per day | Peak Pressure (kPa) | Max. Exposure per day | Peak Pressure (kPa) | Max. Exposure per day | Peak Pressure (kPa) | Max. Exposure per day |
| SS GP | 1.0 | 64832 | 3.0 | 1195 | 2.2 | 2802 | 1.4 | 11748* |
| SS | 1.7 | 7236 | 3.3 | 837 | 3.5 | 632 | 1.1 | 23796* |
| APFSDS | | | | | | | | |
| SS | 1.6 | 10175 | 3.1 | 830 | 3.5 | 1254 | 1.0 | 39039* |
| APFSDS – Elevated | | | | | | | | |
| Burst GP | 1.1 | 35054 | 3.2 | 2075 | 2.3 | 3591 | 0.9 | 60452* |

*Invalid data – a worst case of 200 ms B-duration used in maximum exposures per day calculation

Accelerations were measured at four locations: the gun shield, the turret roof, the hull rear, and the hull front. Two transducers were used on the gun shield (one transverse and one vertical), three on the turret roof (one transverse, one vertical, and one longitudinal), three on the hull rear (one transverse, one vertical, and one longitudinal), and one vertical on the hull front. The sampling

rate was decreased from 200 KHz to 50 KHz after the first two shots. A sample shock response time plot, i.e., static acceleration as a function of natural frequency, for all shots recorded at the gun shield location is shown in Figure 16. All the plots for all the locations are shown in Appendix C. On all the plots, the upper and lower limits from the 1993 pliant structure ballistic shock specifications are shown. These limits were established in previous testing to show the effect of shock on a vehicle and its components (instrumentation, gauges, computers, etc.) (Walton 1994). The limits show the design criteria for the shock. The upper band is the maximum allowable and the lower band has a safety factor incorporated. The plots in Appendix C show that the gun shield location and the turret top were the worst case conditions for the maximum shock. Only one orientation for each of these locations was above the lower limit, and this was only slightly above the bottom band. The other locations were well below the bottom band, and therefore, all are well within design specifications. Based on these initial firings of the gun, no adverse effects on the BFV were determined.

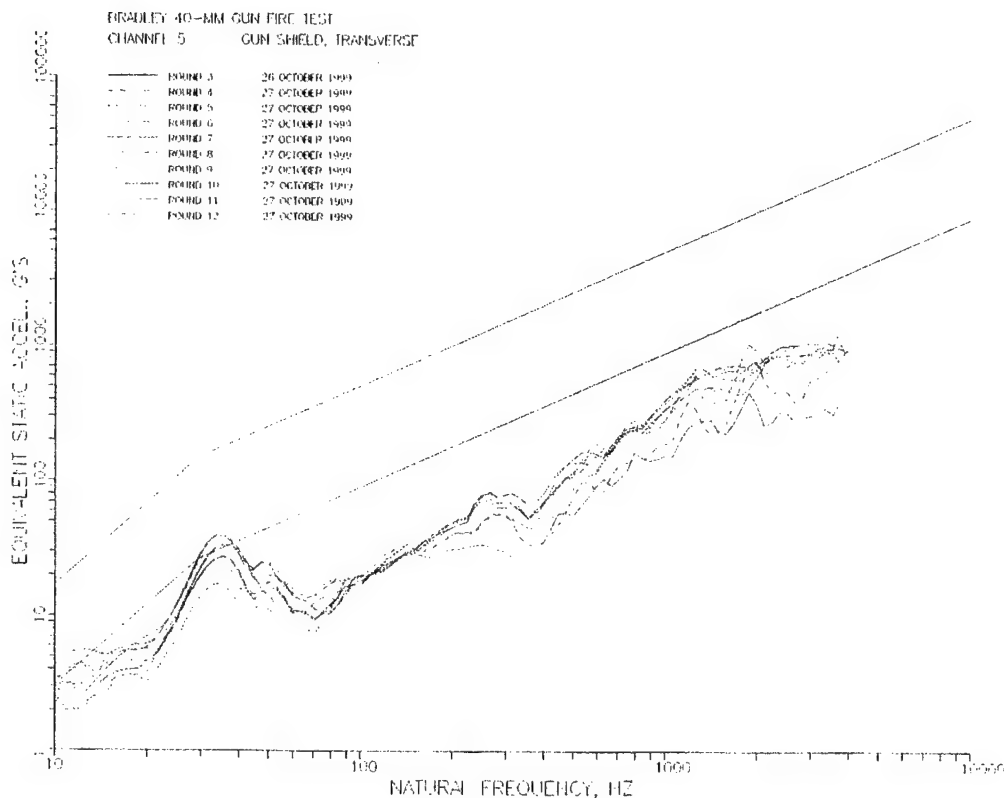


Figure 16. Sample Plot of the Measured Accelerations on the Gun Shield.

6. Summary

The evaluation of the 40-mm CTAI gun system was a great success. It allowed CTAI the opportunity to present their gun system on the BFV. The U.S. Government had the opportunity to evaluate the performance of the new gun system. This system was shown to fit into the BFV nicely.

The APFSDS ammunition performed as advertised, with a muzzle velocity of approximately 1640 m/s and a velocity decay of 0.12 m/s/m. These values will give the 40-mm CTAI APFSDS a high velocity at the target for typical engagement ranges. The measured shock to the vehicle and overpressures within the vehicle during firing all appear to be at acceptable levels for these initial experiments.

The program was a good cooperative endeavor and should be continued. It has increased the database for the U.S. Government and allows the contractors to demonstrate their ammunition in an unbiased format.

References

Walton, Scott, "Memorandum on the Bradley 40-mm Gun Firing Test," No. 00-BAB-01, Aberdeen Test Center, Aberdeen Proving Ground, MD, January 10, 2000.

Walton, W.S., and Bucci, J., "The Rationale for Shock Specifications and Shock Testing of Armored Ground Combat Vehicles," The Proceedings of the 65th Shock and Vibration Symposium, Vol 1, pp 285-293. San Diego CA, October 31-November 3, 1994.

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APPENDIX A
INDIVIDUAL VELOCITY DATA

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Table A-1. Velocity Data for the GP Projectile, Shot No. 1

W E I B E L S C I E N T I F I C W-1000i #5037

DATE TIME CHANNEL ROUND
991026 16:40:14.068 1-4 1

B2 CASSIDY 40 MM

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.

=====

Velocity Results : Adjusted

(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m | S/N dB | USED |
|------|-------------|------------------|---------------|----------------|------------------|-----------|----------|
| Muzz | 0.000 | 1018.393 | 0.00 | | 689.674 | 0.6772 | 36.1 254 |
| 1 | 24.998 | 1001.725 | 25.24 | -693.057 | 0.6923 | 19.9 | * |
| 2 | 28.429 | 998.893 | 28.67 | -693.522 | 0.6944 | 22.4 | * |
| 3 | 31.866 | 995.100 | 32.10 | -693.987 | 0.6965 | 19.3 | * |
| 4 | 35.296 | 993.470 | 35.52 | -694.451 | 0.6987 | 21.9 | * |
| 5 | 38.726 | 991.873 | 38.92 | -694.915 | 0.7008 | 32.6 | * |
| 6 | 42.157 | 988.747 | 42.32 | -695.380 | 0.7030 | 39.3 | * |
| 7 | 45.587 | 987.308 | 45.71 | -695.844 | 0.7051 | 40.2 | * |
| 8 | 49.018 | 984.127 | 49.09 | -696.308 | 0.7073 | 44.4 | * |
| 9 | 52.448 | 982.225 | 52.46 | -696.773 | 0.7095 | 36.7 | * |
| 10 | 55.885 | 980.832 | 55.83 | -697.238 | 0.7117 | 23.2 | * |
| 11 | 59.315 | 977.396 | 59.19 | -697.702 | 0.7140 | 31.3 | * |
| 12 | 62.746 | 974.929 | 62.54 | -698.167 | 0.7162 | 31.9 | * |
| 13 | 66.176 | 972.585 | 65.88 | -696.178 | 0.7159 | 26.3 | * |
| 14 | 69.606 | 970.780 | 69.21 | -694.428 | 0.7159 | 20.3 | * |
| 15 | 73.037 | 968.125 | 72.53 | -695.462 | 0.7187 | 17.1 | * |
| 16 | 76.474 | 965.059 | 75.85 | -697.180 | 0.7223 | 16.1 | * |
| 17 | 79.904 | 961.301 | 79.16 | -696.680 | 0.7236 | 17.0 | * |
| 18 | 83.334 | 959.683 | 82.46 | -694.396 | 0.7231 | 24.7 | * |
| 19 | 86.765 | 958.116 | 85.75 | -694.365 | 0.7249 | 29.6 | * |
| 20 | 90.195 | 955.352 | 89.03 | -693.343 | 0.7256 | 34.4 | * |
| 21 | 93.626 | 953.402 | 92.30 | -690.688 | 0.7247 | 36.8 | * |
| 22 | 97.056 | 950.629 | 95.57 | -684.849 | 0.7203 | 45.2 | * |
| 23 | 100.493 | 948.557 | 98.83 | -678.445 | 0.7154 | 44.2 | * |
| 24 | 103.923 | 946.298 | 102.08 | -672.548 | 0.7109 | 47.2 | * |
| 25 | 107.354 | 943.869 | 105.32 | -669.154 | 0.7090 | 47.9 | * |
| 26 | 110.784 | 941.686 | 108.56 | -665.563 | 0.7069 | 45.4 | * |
| 27 | 114.214 | 939.460 | 111.78 | -657.909 | 0.7004 | 46.3 | * |
| 28 | 117.645 | 936.959 | 115.00 | -654.541 | 0.6984 | 47.1 | * |
| 29 | 121.082 | 934.704 | 118.22 | -655.320 | 0.7010 | 43.0 | * |
| 30 | 124.512 | 932.572 | 121.42 | -655.248 | 0.7026 | 40.1 | * |
| 31 | 127.942 | 930.181 | 124.62 | -653.127 | 0.7020 | 44.0 | * |
| 32 | 131.373 | 928.003 | 127.81 | -650.604 | 0.7010 | 38.4 | * |
| 33 | 134.803 | 925.752 | 130.99 | -648.485 | 0.7004 | 38.5 | * |
| 34 | 138.234 | 923.603 | 134.16 | -645.705 | 0.6990 | 34.2 | * |
| 35 | 141.664 | 921.650 | 137.32 | -643.211 | 0.6980 | 27.3 | * |
| 36 | 145.101 | 920.665 | 140.49 | -640.464 | 0.6967 | 17.1 | * |
| 37 | 148.531 | 916.894 | 143.64 | -638.038 | 0.6957 | 34.4 | * |
| 38 | 151.962 | 914.715 | 146.78 | -635.414 | 0.6945 | 37.0 | * |

| | | | | | | | |
|----|---------|---------|--------|----------|--------|------|---|
| 39 | 155.392 | 912.481 | 149.91 | -632.547 | 0.6931 | 39.1 | * |
| 40 | 158.822 | 910.388 | 153.04 | -629.854 | 0.6917 | 42.6 | * |
| 41 | 162.253 | 908.239 | 156.16 | -627.531 | 0.6908 | 42.3 | * |
| 42 | 165.683 | 906.081 | 159.27 | -625.061 | 0.6898 | 44.4 | * |
| 43 | 169.120 | 904.009 | 162.38 | -623.188 | 0.6893 | 41.5 | * |
| 44 | 172.550 | 901.856 | 165.48 | -620.871 | 0.6884 | 43.1 | * |
| 45 | 175.981 | 899.728 | 168.57 | -618.550 | 0.6875 | 45.6 | * |
| 46 | 179.411 | 897.626 | 171.65 | -616.021 | 0.6863 | 43.5 | * |
| 47 | 182.842 | 895.622 | 174.73 | -612.914 | 0.6844 | 44.1 | * |
| 48 | 186.272 | 893.537 | 177.80 | -608.018 | 0.6805 | 43.0 | * |
| 49 | 189.709 | 891.439 | 180.87 | -602.102 | 0.6754 | 47.2 | * |
| 50 | 193.139 | 889.379 | 183.92 | -599.402 | 0.6740 | 43.5 | * |
| 51 | 196.570 | 887.332 | 186.97 | -596.892 | 0.6727 | 44.3 | * |
| 52 | 200.000 | 885.285 | 190.01 | -594.290 | 0.6713 | 45.1 | * |
| 53 | 203.430 | 883.217 | 193.04 | -591.657 | 0.6699 | 48.6 | * |
| 54 | 206.861 | 881.217 | 196.07 | -589.087 | 0.6685 | 47.9 | * |
| 55 | 210.291 | 879.191 | 199.09 | -586.512 | 0.6671 | 47.1 | * |
| 56 | 213.728 | 877.157 | 202.10 | -583.950 | 0.6657 | 48.4 | * |
| 57 | 217.158 | 875.166 | 205.11 | -581.411 | 0.6643 | 47.2 | * |
| 58 | 220.589 | 873.170 | 208.11 | -578.952 | 0.6630 | 47.7 | * |
| 59 | 224.019 | 871.208 | 211.10 | -576.482 | 0.6617 | 46.2 | * |
| 60 | 227.450 | 869.241 | 214.09 | -573.785 | 0.6601 | 46.5 | * |
| 61 | 230.880 | 867.305 | 217.06 | -571.246 | 0.6587 | 48.8 | * |
| 62 | 234.317 | 865.330 | 220.04 | -568.752 | 0.6573 | 46.7 | * |
| 63 | 237.747 | 863.372 | 223.01 | -566.177 | 0.6558 | 49.3 | * |
| 64 | 241.178 | 861.423 | 225.97 | -563.568 | 0.6542 | 50.1 | * |
| 65 | 244.608 | 859.529 | 228.92 | -561.145 | 0.6529 | 47.3 | * |
| 66 | 248.038 | 857.623 | 231.86 | -558.677 | 0.6515 | 45.6 | * |
| 67 | 251.469 | 855.690 | 234.80 | -556.136 | 0.6499 | 48.2 | * |
| 68 | 254.899 | 853.745 | 237.73 | -553.828 | 0.6487 | 45.3 | * |
| 69 | 258.336 | 851.885 | 240.66 | -551.464 | 0.6474 | 46.3 | * |
| 70 | 261.766 | 849.983 | 243.58 | -549.109 | 0.6460 | 46.3 | * |
| 71 | 265.197 | 848.106 | 246.50 | -546.774 | 0.6447 | 45.6 | * |
| 72 | 268.627 | 846.263 | 249.40 | -544.479 | 0.6434 | 48.3 | * |
| 73 | 272.058 | 844.390 | 252.30 | -542.245 | 0.6422 | 47.4 | * |
| 74 | 275.488 | 842.470 | 255.19 | -539.798 | 0.6407 | 46.5 | * |
| 75 | 278.919 | 840.670 | 258.08 | -537.265 | 0.6391 | 43.9 | * |
| 76 | 282.355 | 838.886 | 260.97 | -534.900 | 0.6377 | 45.2 | * |
| 77 | 285.786 | 836.962 | 263.84 | -532.396 | 0.6361 | 45.2 | * |
| 78 | 289.216 | 835.208 | 266.71 | -530.506 | 0.6352 | 48.4 | * |
| 79 | 292.647 | 833.378 | 269.57 | -529.993 | 0.6359 | 43.4 | * |
| 80 | 296.077 | 831.548 | 272.43 | -530.169 | 0.6375 | 42.5 | * |
| 81 | 299.507 | 829.739 | 275.28 | -528.737 | 0.6372 | 47.8 | * |
| 82 | 302.944 | 827.989 | 278.13 | -527.197 | 0.6367 | 44.8 | * |
| 83 | 306.374 | 826.193 | 280.96 | -525.806 | 0.6364 | 45.3 | * |
| 84 | 309.805 | 824.392 | 283.80 | -524.150 | 0.6358 | 45.4 | * |
| 85 | 313.235 | 822.575 | 286.62 | -522.044 | 0.6347 | 45.5 | * |
| 86 | 316.666 | 820.893 | 289.44 | -519.880 | 0.6334 | 43.4 | * |
| 87 | 320.096 | 819.169 | 292.25 | -517.816 | 0.6323 | 42.4 | * |
| 88 | 323.526 | 817.432 | 295.06 | -515.525 | 0.6309 | 41.2 | * |
| 89 | 326.963 | 815.686 | 297.86 | -512.908 | 0.6290 | 43.0 | * |
| 90 | 330.394 | 814.018 | 300.66 | -510.999 | 0.6281 | 38.5 | * |
| 91 | 333.824 | 811.512 | 303.45 | -508.594 | 0.6265 | 29.1 | * |
| 92 | 337.254 | 809.164 | 306.23 | -506.081 | 0.6247 | 32.2 | * |
| 93 | 340.685 | 808.397 | 309.00 | -503.451 | 0.6228 | 37.5 | * |
| 94 | 344.115 | 806.458 | 311.77 | -500.613 | 0.6206 | 42.0 | * |
| 95 | 347.552 | 804.603 | 314.54 | -497.631 | 0.6182 | 41.3 | * |
| 96 | 350.982 | 803.227 | 317.30 | -494.550 | 0.6157 | 39.8 | * |

| | | | | | | | |
|-----|---------|---------|--------|----------|--------|------|---|
| 97 | 354.413 | 801.630 | 320.05 | -491.448 | 0.6131 | 35.3 | * |
| 98 | 357.843 | 800.203 | 322.80 | -488.702 | 0.6110 | 33.9 | * |
| 99 | 361.274 | 798.339 | 325.54 | -484.985 | 0.6076 | 34.7 | * |
| 100 | 364.704 | 796.636 | 328.28 | -481.131 | 0.6040 | 35.8 | * |
| 101 | 368.134 | 795.077 | 331.01 | -477.330 | 0.6005 | 36.1 | * |
| 102 | 371.571 | 793.249 | 333.74 | -473.451 | 0.5968 | 35.0 | * |
| 103 | 375.002 | 791.875 | 336.45 | -470.639 | 0.5944 | 35.0 | * |
| 104 | 378.432 | 789.998 | 339.17 | -469.628 | 0.5944 | 34.8 | * |
| 105 | 381.862 | 788.440 | 341.87 | -469.246 | 0.5951 | 36.0 | * |
| 106 | 385.293 | 786.835 | 344.58 | -467.683 | 0.5943 | 36.2 | * |
| 107 | 388.723 | 785.225 | 347.27 | -466.971 | 0.5947 | 33.7 | * |
| 108 | 392.160 | 783.667 | 349.97 | -465.426 | 0.5939 | 34.0 | * |
| 109 | 395.590 | 782.104 | 352.66 | -463.515 | 0.5927 | 36.8 | * |
| 110 | 399.021 | 780.392 | 355.34 | -461.109 | 0.5908 | 36.9 | * |
| 111 | 402.451 | 778.970 | 358.01 | -458.790 | 0.5890 | 37.4 | * |
| 112 | 405.882 | 777.364 | 360.68 | -456.894 | 0.5878 | 39.6 | * |
| 113 | 409.312 | 775.848 | 363.34 | -455.196 | 0.5868 | 38.7 | * |
| 114 | 412.742 | 774.235 | 366.00 | -453.183 | 0.5853 | 43.4 | * |
| 115 | 416.179 | 772.714 | 368.66 | -450.692 | 0.5833 | 41.3 | * |
| 116 | 419.610 | 771.126 | 371.31 | -448.931 | 0.5822 | 38.9 | * |
| 117 | 423.040 | 769.720 | 373.95 | -446.973 | 0.5808 | 36.2 | * |
| 118 | 426.470 | 767.979 | 376.59 | -444.945 | 0.5793 | 38.1 | * |
| 119 | 429.901 | 766.493 | 379.22 | -443.178 | 0.5782 | 40.0 | * |
| 120 | 433.331 | 765.009 | 381.85 | -441.418 | 0.5770 | 40.4 | * |
| 121 | 436.762 | 763.512 | 384.47 | -439.611 | 0.5758 | 40.3 | * |
| 122 | 440.198 | 762.047 | 387.09 | -438.055 | 0.5749 | 41.2 | * |
| 123 | 443.629 | 760.480 | 389.70 | -436.038 | 0.5734 | 39.2 | * |
| 124 | 447.059 | 758.968 | 392.31 | -434.105 | 0.5719 | 40.8 | * |
| 125 | 450.490 | 757.416 | 394.91 | -432.106 | 0.5704 | 38.5 | * |
| 126 | 453.920 | 756.048 | 397.51 | -430.287 | 0.5691 | 39.6 | * |
| 127 | 457.350 | 754.577 | 400.10 | -428.560 | 0.5679 | 36.5 | * |
| 128 | 460.787 | 753.146 | 402.69 | -426.610 | 0.5665 | 35.8 | * |
| 129 | 464.218 | 751.657 | 405.27 | -425.031 | 0.5655 | 37.5 | * |
| 130 | 467.648 | 750.385 | 407.84 | -422.705 | 0.5635 | 37.2 | * |
| 131 | 471.078 | 748.744 | 410.42 | -421.130 | 0.5624 | 39.1 | * |
| 132 | 474.509 | 747.294 | 412.98 | -419.381 | 0.5612 | 38.3 | * |
| 133 | 477.939 | 745.845 | 415.54 | -417.596 | 0.5599 | 38.8 | * |
| 134 | 481.370 | 744.436 | 418.10 | -415.796 | 0.5585 | 38.9 | * |
| 135 | 484.807 | 743.077 | 420.65 | -414.117 | 0.5573 | 36.4 | * |
| 136 | 488.237 | 741.616 | 423.20 | -412.841 | 0.5567 | 40.8 | * |
| 137 | 491.667 | 740.197 | 425.74 | -411.329 | 0.5557 | 43.3 | * |
| 138 | 495.098 | 738.766 | 428.28 | -410.063 | 0.5551 | 43.7 | * |
| 139 | 498.528 | 737.271 | 430.81 | -408.540 | 0.5540 | 44.3 | * |
| 140 | 501.959 | 736.040 | 433.34 | -406.972 | 0.5530 | 39.6 | * |
| 141 | 505.395 | 734.490 | 435.87 | -405.434 | 0.5519 | 40.7 | * |
| 142 | 508.826 | 733.288 | 438.38 | -403.598 | 0.5505 | 37.9 | * |
| 143 | 512.256 | 731.861 | 440.90 | -401.807 | 0.5490 | 39.6 | * |
| 144 | 515.686 | 730.426 | 443.40 | -400.422 | 0.5482 | 38.7 | * |
| 145 | 519.117 | 729.169 | 445.91 | -399.051 | 0.5473 | 39.0 | * |
| 146 | 522.547 | 727.729 | 448.41 | -397.560 | 0.5463 | 37.0 | * |
| 147 | 525.978 | 726.393 | 450.90 | -395.961 | 0.5451 | 36.7 | * |
| 148 | 529.415 | 724.863 | 453.39 | -394.366 | 0.5440 | 38.4 | * |
| 149 | 532.845 | 723.661 | 455.88 | -392.743 | 0.5427 | 35.0 | * |
| 150 | 536.275 | 722.323 | 458.36 | -391.224 | 0.5416 | 36.7 | * |
| 151 | 539.706 | 720.990 | 460.83 | -389.959 | 0.5409 | 35.5 | * |
| 152 | 543.136 | 719.631 | 463.31 | -388.601 | 0.5400 | 36.6 | * |
| 153 | 546.566 | 718.257 | 465.77 | -387.092 | 0.5389 | 38.6 | * |
| 154 | 549.997 | 716.981 | 468.23 | -385.910 | 0.5383 | 36.2 | * |

| | | | | | | | |
|-----|---------|---------|--------|----------|--------|------|---|
| 155 | 553.434 | 715.647 | 470.70 | -384.296 | 0.5370 | 37.4 | * |
| 156 | 556.864 | 714.290 | 473.15 | -382.883 | 0.5360 | 36.2 | * |
| 157 | 560.294 | 712.982 | 475.60 | -381.378 | 0.5349 | 35.2 | * |
| 158 | 563.725 | 711.736 | 478.04 | -379.932 | 0.5338 | 36.0 | * |
| 159 | 567.155 | 710.441 | 480.48 | -378.498 | 0.5328 | 36.8 | * |
| 160 | 570.586 | 709.078 | 482.91 | -377.134 | 0.5318 | 36.8 | * |
| 161 | 574.022 | 707.867 | 485.35 | -376.148 | 0.5314 | 35.5 | * |
| 162 | 577.453 | 706.619 | 487.77 | -374.833 | 0.5305 | 31.9 | * |
| 163 | 580.883 | 705.215 | 490.20 | -373.506 | 0.5296 | 32.0 | * |
| 164 | 584.314 | 704.037 | 492.61 | -372.183 | 0.5287 | 33.2 | * |
| 165 | 587.744 | 702.691 | 495.03 | -370.971 | 0.5279 | 33.9 | * |
| 166 | 591.175 | 701.446 | 497.43 | -369.750 | 0.5271 | 32.4 | * |
| 167 | 594.605 | 700.160 | 499.84 | -368.399 | 0.5262 | 32.5 | * |
| 168 | 598.042 | 698.949 | 502.24 | -367.076 | 0.5252 | 34.1 | * |
| 169 | 601.472 | 697.667 | 504.64 | -366.039 | 0.5247 | 34.5 | * |
| 170 | 604.902 | 696.346 | 507.03 | -364.632 | 0.5236 | 34.8 | * |
| 171 | 608.333 | 695.153 | 509.42 | -363.230 | 0.5225 | 34.2 | * |
| 172 | 611.763 | 693.909 | 511.80 | -361.956 | 0.5216 | 33.6 | * |
| 173 | 615.194 | 692.660 | 514.18 | -360.595 | 0.5206 | 33.8 | * |
| 174 | 618.631 | 691.420 | 516.56 | -359.091 | 0.5194 | 33.3 | * |
| 175 | 622.061 | 690.120 | 518.92 | -357.597 | 0.5181 | 33.5 | * |
| 176 | 625.491 | 688.946 | 521.29 | -356.335 | 0.5172 | 33.7 | * |
| 177 | 628.922 | 687.766 | 523.65 | -354.711 | 0.5158 | 32.6 | * |
| 178 | 632.352 | 686.502 | 526.01 | -353.214 | 0.5145 | 31.1 | * |
| 179 | 635.783 | 685.345 | 528.36 | -351.808 | 0.5134 | 32.7 | * |
| 180 | 639.213 | 684.154 | 530.71 | -350.252 | 0.5120 | 33.4 | * |
| 181 | 642.650 | 682.850 | 533.06 | -348.711 | 0.5106 | 36.0 | * |
| 182 | 646.080 | 681.806 | 535.40 | -347.415 | 0.5096 | 34.4 | * |
| 183 | 649.510 | 680.540 | 537.74 | -346.252 | 0.5088 | 33.7 | * |
| 184 | 652.941 | 679.370 | 540.07 | -344.894 | 0.5077 | 36.9 | * |
| 185 | 656.371 | 678.183 | 542.40 | -343.269 | 0.5062 | 36.0 | * |
| 186 | 659.802 | 676.960 | 544.72 | -342.003 | 0.5052 | 35.8 | * |
| 187 | 663.238 | 675.839 | 547.05 | -340.836 | 0.5043 | 34.4 | * |
| 188 | 666.669 | 674.614 | 549.36 | -339.619 | 0.5034 | 36.4 | * |
| 189 | 670.099 | 673.580 | 551.68 | -338.427 | 0.5025 | 34.9 | * |
| 190 | 673.530 | 672.348 | 553.98 | -337.290 | 0.5017 | 35.9 | * |
| 191 | 676.960 | 671.216 | 556.29 | -335.983 | 0.5006 | 34.0 | * |
| 192 | 680.391 | 670.027 | 558.59 | -334.600 | 0.4994 | 33.1 | * |
| 193 | 683.821 | 668.921 | 560.89 | -333.347 | 0.4984 | 35.6 | * |
| 194 | 687.258 | 667.736 | 563.18 | -331.815 | 0.4969 | 35.4 | * |
| 195 | 690.688 | 666.543 | 565.47 | -330.426 | 0.4957 | 35.6 | * |
| 196 | 694.119 | 665.464 | 567.76 | -329.029 | 0.4944 | 33.9 | * |
| 197 | 697.549 | 664.394 | 570.04 | -327.653 | 0.4932 | 33.7 | * |
| 198 | 700.979 | 663.235 | 572.31 | -326.333 | 0.4920 | 36.1 | * |
| 199 | 704.410 | 662.058 | 574.59 | -324.994 | 0.4909 | 36.5 | * |
| 200 | 707.840 | 661.056 | 576.86 | -323.556 | 0.4895 | 34.0 | * |
| 201 | 711.277 | 659.880 | 579.13 | -321.900 | 0.4878 | 36.9 | * |
| 202 | 714.707 | 658.682 | 581.39 | -320.504 | 0.4865 | 34.4 | * |
| 203 | 718.138 | 657.714 | 583.65 | -319.084 | 0.4852 | 38.4 | * |
| 204 | 721.568 | 656.604 | 585.90 | -317.708 | 0.4839 | 37.1 | * |
| 205 | 724.999 | 655.506 | 588.15 | -316.314 | 0.4825 | 36.6 | * |
| 206 | 728.429 | 654.499 | 590.40 | -314.938 | 0.4812 | 38.2 | * |
| 207 | 731.866 | 653.317 | 592.64 | -313.493 | 0.4798 | 37.5 | * |
| 208 | 735.296 | 652.293 | 594.88 | -312.364 | 0.4789 | 34.2 | * |
| 209 | 738.727 | 651.200 | 597.12 | -310.850 | 0.4773 | 35.4 | * |
| 210 | 742.157 | 650.129 | 599.35 | -309.567 | 0.4761 | 34.8 | * |
| 211 | 745.587 | 649.093 | 601.58 | -308.450 | 0.4752 | 36.8 | * |
| 212 | 749.018 | 648.042 | 603.81 | -307.136 | 0.4739 | 36.5 | * |

| | | | | | | | |
|-----|---------|---------|--------|----------|--------|------|---|
| 213 | 752.448 | 647.055 | 606.03 | -305.968 | 0.4729 | 38.0 | * |
| 214 | 755.885 | 646.002 | 608.25 | -305.136 | 0.4724 | 36.7 | * |
| 215 | 759.315 | 644.834 | 610.46 | -304.290 | 0.4718 | 35.7 | * |
| 216 | 762.746 | 643.806 | 612.67 | -303.275 | 0.4710 | 35.6 | * |
| 217 | 766.176 | 642.825 | 614.88 | -302.108 | 0.4700 | 36.2 | * |
| 218 | 769.606 | 641.730 | 617.08 | -300.982 | 0.4690 | 35.3 | * |
| 219 | 773.037 | 640.850 | 619.28 | -300.203 | 0.4685 | 34.1 | * |
| 220 | 776.474 | 639.712 | 621.48 | -299.367 | 0.4680 | 35.4 | * |
| 221 | 779.904 | 638.710 | 623.68 | -298.577 | 0.4675 | 35.5 | * |
| 222 | 783.335 | 637.750 | 625.87 | -297.858 | 0.4671 | 31.4 | * |
| 223 | 786.765 | 636.650 | 628.05 | -297.040 | 0.4666 | 32.0 | * |
| 224 | 790.195 | 635.682 | 630.23 | -296.343 | 0.4662 | 30.7 | * |
| 225 | 793.626 | 634.663 | 632.41 | -295.181 | 0.4651 | 33.0 | * |
| 226 | 797.056 | 633.555 | 634.59 | -294.556 | 0.4649 | 31.1 | * |
| 227 | 800.493 | 632.616 | 636.76 | -294.163 | 0.4650 | 30.6 | * |
| 228 | 803.923 | 631.584 | 638.93 | -293.748 | 0.4651 | 31.3 | * |
| 229 | 807.354 | 630.731 | 641.10 | -293.098 | 0.4648 | 29.9 | * |
| 230 | 810.784 | 629.590 | 643.26 | -292.112 | 0.4640 | 30.4 | * |
| 231 | 814.215 | 628.582 | 645.42 | -290.855 | 0.4627 | 30.0 | * |
| 232 | 817.645 | 627.571 | 647.57 | -289.252 | 0.4609 | 29.3 | * |
| 233 | 821.075 | 626.616 | 649.72 | -287.727 | 0.4592 | 27.7 | * |
| 234 | 824.512 | 625.584 | 651.87 | -286.826 | 0.4585 | 26.5 | * |
| 235 | 827.943 | 624.675 | 654.02 | -285.331 | 0.4568 | 28.3 | * |
| 236 | 831.373 | 623.603 | 656.16 | -283.895 | 0.4552 | 28.3 | * |
| 237 | 834.803 | 622.768 | 658.30 | -282.993 | 0.4545 | 25.3 | * |
| 238 | 838.234 | 621.658 | 660.43 | -282.190 | 0.4539 | 27.1 | * |
| 239 | 841.664 | 620.456 | 662.56 | -281.803 | 0.4540 | 25.1 | * |
| 240 | 845.101 | 619.664 | 664.69 | -281.114 | 0.4536 | 25.2 | * |
| 241 | 848.531 | 618.672 | 666.82 | -281.041 | 0.4541 | 20.7 | * |
| 242 | 851.962 | 617.893 | 668.94 | -280.997 | 0.4548 | 20.2 | * |
| 243 | 855.392 | 617.058 | 671.06 | -281.297 | 0.4559 | 19.9 | * |
| 244 | 858.822 | 616.103 | 673.17 | -281.506 | 0.4570 | 18.0 | * |
| 245 | 862.253 | 615.451 | 675.28 | -281.715 | 0.4581 | 15.8 | * |
| 246 | 865.683 | 614.126 | 677.39 | -281.923 | 0.4591 | 17.3 | * |
| 247 | 869.120 | 612.827 | 679.50 | -282.132 | 0.4602 | 19.6 | * |
| 248 | 872.551 | 612.695 | 681.60 | -282.341 | 0.4612 | 15.2 | * |
| 249 | 875.981 | 611.085 | 683.70 | -282.550 | 0.4623 | 14.6 | * |
| 250 | 879.411 | 610.270 | 685.80 | -282.759 | 0.4634 | 15.0 | * |
| 251 | 882.842 | 609.166 | 687.89 | -282.968 | 0.4645 | 16.4 | * |
| 252 | 886.272 | 608.338 | 689.98 | -283.176 | 0.4656 | 12.6 | * |
| 253 | 889.709 | 607.200 | 692.06 | -283.385 | 0.4667 | 12.6 | * |
| 254 | 893.139 | 606.261 | 694.15 | -283.594 | 0.4677 | 1.8 | |
| 255 | 896.570 | 605.277 | 696.22 | -283.803 | 0.4688 | -1.0 | |
| 256 | 900.000 | 604.142 | 698.30 | -284.011 | 0.4699 | 7.1 | * |

Table A-2. Velocity Data for the GP Projectile, Shot No. 2

W E I B E L S C I E N T I F I C W-1000i #5037

DATE TIME CHANNEL ROUND
991026 17:17:53.403 1-4 2

B2 CASSIDY 40 MM

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.

=====

Velocity Results : Adjusted

(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1036.216 | 0.00 | -715.562 | 0.6906 |
| 1 | 19.431 | 1022.316 | 20.00 | -715.235 | 0.6996 |
| 2 | 39.130 | 1008.233 | 40.00 | -714.902 | 0.7091 |
| 3 | 59.108 | 993.960 | 60.00 | -714.562 | 0.7189 |
| 4 | 79.378 | 979.487 | 80.00 | -714.217 | 0.7292 |
| 5 | 99.953 | 964.662 | 100.00 | -699.103 | 0.7247 |
| 6 | 120.840 | 950.441 | 120.00 | -673.593 | 0.7087 |
| 7 | 142.040 | 936.433 | 140.00 | -653.721 | 0.6981 |
| 8 | 163.557 | 922.567 | 160.00 | -638.622 | 0.6922 |
| 9 | 185.399 | 908.858 | 180.00 | -617.963 | 0.6799 |
| 10 | 207.570 | 895.380 | 200.00 | -599.506 | 0.6696 |
| 11 | 230.075 | 882.122 | 220.00 | -581.472 | 0.6592 |
| 12 | 252.917 | 869.083 | 240.00 | -563.280 | 0.6481 |
| 13 | 276.102 | 856.273 | 260.00 | -546.838 | 0.6386 |
| 14 | 299.631 | 843.669 | 280.00 | -543.410 | 0.6441 |
| 15 | 323.523 | 830.679 | 300.00 | -524.586 | 0.6315 |
| 16 | 347.784 | 818.276 | 320.00 | -495.563 | 0.6056 |
| 17 | 372.399 | 806.787 | 340.00 | -469.066 | 0.5814 |
| 18 | 397.371 | 795.080 | 360.00 | -463.816 | 0.5834 |
| 19 | 422.712 | 783.482 | 380.00 | -451.504 | 0.5763 |
| 20 | 448.427 | 772.099 | 400.00 | -438.590 | 0.5681 |
| 21 | 474.520 | 760.905 | 420.00 | -425.463 | 0.5592 |
| 22 | 500.998 | 749.844 | 440.00 | -415.349 | 0.5539 |
| 23 | 527.867 | 738.858 | 460.00 | -407.147 | 0.5511 |
| 24 | 555.139 | 727.936 | 480.00 | -397.567 | 0.5462 |
| 25 | 582.820 | 717.159 | 500.00 | -387.712 | 0.5406 |
| 26 | 610.918 | 706.465 | 520.00 | -379.202 | 0.5368 |
| 27 | 639.443 | 695.844 | 540.00 | -369.734 | 0.5314 |
| 28 | 668.404 | 685.372 | 560.00 | -359.087 | 0.5239 |
| 29 | 697.808 | 675.045 | 580.00 | -348.372 | 0.5161 |
| 30 | 727.660 | 664.934 | 600.00 | -337.224 | 0.5072 |
| 31 | 757.967 | 654.959 | 620.00 | -327.848 | 0.5006 |
| 32 | 788.736 | 645.101 | 640.00 | -316.615 | 0.4908 |
| 33 | 819.971 | 635.630 | 660.00 | -312.129 | 0.4911 |
| 34 | 851.683 | 625.380 | 680.00 | -351.360 | 0.5618 |
| 35 | 883.964 | 613.502 | 700.00 | -391.797 | 0.6386 |

Table A-3. Velocity Data for the GP Projectile, Shot No. 3

W E I B E L S C I E N T I F I C W-1000i #5037

DATE TIME CHANNEL ROUND
991026 17:57:13.913 1-4 3

B2 CASSIDY 40 MM

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.

=====

Velocity Results : Adjusted

(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1032.809 | 0.00 | -745.864 | 0.7222 |
| 1 | 19.502 | 1018.326 | 20.00 | -739.430 | 0.7261 |
| 2 | 39.283 | 1003.763 | 40.00 | -732.903 | 0.7302 |
| 3 | 59.355 | 989.120 | 60.00 | -726.281 | 0.7343 |
| 4 | 79.727 | 974.392 | 80.00 | -719.559 | 0.7385 |
| 5 | 100.413 | 959.395 | 100.00 | -702.310 | 0.7320 |
| 6 | 121.419 | 944.972 | 120.00 | -675.784 | 0.7151 |
| 7 | 142.743 | 930.927 | 140.00 | -654.020 | 0.7026 |
| 8 | 164.389 | 916.999 | 160.00 | -637.195 | 0.6949 |
| 9 | 186.367 | 903.107 | 180.00 | -617.995 | 0.6843 |
| 10 | 208.680 | 889.637 | 200.00 | -595.991 | 0.6699 |
| 11 | 231.330 | 876.392 | 220.00 | -577.431 | 0.6589 |
| 12 | 254.323 | 863.310 | 240.00 | -560.672 | 0.6495 |
| 13 | 277.665 | 850.424 | 260.00 | -543.152 | 0.6387 |
| 14 | 301.360 | 837.817 | 280.00 | -529.025 | 0.6314 |
| 15 | 325.413 | 825.212 | 300.00 | -514.741 | 0.6238 |
| 16 | 349.834 | 812.793 | 320.00 | -498.415 | 0.6132 |
| 17 | 374.626 | 800.686 | 340.00 | -481.303 | 0.6011 |
| 18 | 399.790 | 788.854 | 360.00 | -465.044 | 0.5895 |
| 19 | 425.334 | 777.151 | 380.00 | -451.853 | 0.5814 |
| 20 | 451.262 | 765.617 | 400.00 | -438.574 | 0.5728 |
| 21 | 477.581 | 754.254 | 420.00 | -422.703 | 0.5604 |
| 22 | 504.295 | 743.184 | 440.00 | -407.467 | 0.5483 |
| 23 | 531.404 | 732.355 | 460.00 | -395.634 | 0.5402 |
| 24 | 558.917 | 721.593 | 480.00 | -387.287 | 0.5367 |
| 25 | 586.842 | 710.885 | 500.00 | -377.626 | 0.5312 |
| 26 | 615.188 | 700.337 | 520.00 | -364.293 | 0.5202 |
| 27 | 643.957 | 690.093 | 540.00 | -350.893 | 0.5085 |
| 28 | 673.152 | 680.016 | 560.00 | -341.437 | 0.5021 |
| 29 | 702.783 | 670.013 | 580.00 | -332.693 | 0.4966 |
| 30 | 732.855 | 660.162 | 600.00 | -323.146 | 0.4895 |
| 31 | 763.376 | 650.443 | 620.00 | -313.866 | 0.4825 |
| 32 | 794.354 | 640.865 | 640.00 | -303.268 | 0.4732 |
| 33 | 825.792 | 631.517 | 660.00 | -291.326 | 0.4613 |
| 34 | 857.693 | 622.401 | 680.00 | -284.358 | 0.4569 |
| 35 | 890.064 | 613.291 | 700.00 | -278.691 | 0.4544 |

Table A-4. Velocity Data for the GP Projectile, Shot No. 4

W E I B E L S C I E N T I F I C W-1000i #5037

DATE TIME CHANNEL ROUND
991027 10:23:56.336 1-4 4

B2 CASSIDY 40 GPI

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.

=====

Velocity Results : Adjusted

(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1030.597 | 0.00 | -652.350 | 0.6330 |
| 1 | 19.528 | 1017.669 | 20.00 | -671.666 | 0.6600 |
| 2 | 39.311 | 1004.188 | 40.00 | -691.233 | 0.6884 |
| 3 | 59.367 | 990.125 | 60.00 | -711.070 | 0.7182 |
| 4 | 79.719 | 975.258 | 80.00 | -724.872 | 0.7433 |
| 5 | 100.388 | 960.175 | 100.00 | -708.793 | 0.7382 |
| 6 | 121.376 | 945.702 | 120.00 | -686.454 | 0.7259 |
| 7 | 142.688 | 931.291 | 140.00 | -665.383 | 0.7145 |
| 8 | 164.329 | 917.064 | 160.00 | -645.290 | 0.7037 |
| 9 | 186.307 | 903.085 | 180.00 | -621.915 | 0.6887 |
| 10 | 208.621 | 889.561 | 200.00 | -597.526 | 0.6717 |
| 11 | 231.274 | 876.284 | 220.00 | -576.229 | 0.6576 |
| 12 | 254.269 | 863.283 | 240.00 | -556.778 | 0.6450 |
| 13 | 277.610 | 850.505 | 260.00 | -540.164 | 0.6351 |
| 14 | 301.301 | 837.918 | 280.00 | -528.716 | 0.6310 |
| 15 | 325.351 | 825.275 | 300.00 | -518.983 | 0.6289 |
| 16 | 349.773 | 812.700 | 320.00 | -502.512 | 0.6183 |
| 17 | 374.568 | 800.590 | 340.00 | -481.702 | 0.6017 |
| 18 | 399.738 | 788.680 | 360.00 | -467.046 | 0.5922 |
| 19 | 425.288 | 776.940 | 380.00 | -452.898 | 0.5829 |
| 20 | 451.223 | 765.372 | 400.00 | -439.603 | 0.5744 |
| 21 | 477.552 | 753.945 | 420.00 | -427.818 | 0.5674 |
| 22 | 504.279 | 742.684 | 440.00 | -414.627 | 0.5583 |
| 23 | 531.412 | 731.615 | 460.00 | -401.312 | 0.5485 |
| 24 | 558.955 | 720.744 | 480.00 | -388.713 | 0.5393 |
| 25 | 586.913 | 710.068 | 500.00 | -373.351 | 0.5258 |
| 26 | 615.288 | 699.711 | 520.00 | -358.725 | 0.5127 |
| 27 | 644.080 | 689.571 | 540.00 | -346.693 | 0.5028 |
| 28 | 673.295 | 679.629 | 560.00 | -334.965 | 0.4929 |
| 29 | 702.937 | 669.856 | 580.00 | -324.366 | 0.4842 |
| 30 | 733.009 | 660.302 | 600.00 | -315.207 | 0.4774 |
| 31 | 763.521 | 650.728 | 620.00 | -308.242 | 0.4737 |
| 32 | 794.480 | 641.408 | 640.00 | -298.675 | 0.4657 |
| 33 | 825.888 | 632.050 | 660.00 | -306.328 | 0.4847 |
| 34 | 857.780 | 622.105 | 680.00 | -317.383 | 0.5102 |
| 35 | 890.201 | 611.635 | 700.00 | -328.618 | 0.5373 |

Table A-5. Velocity Data for the APFSDS Projectile, Shot No. 5

W E I B E L S C I E N T I F I C W-1000i #5037

DATE TIME CHANNEL ROUND
991027 11:08:54.955 1-4 5

B2 CASSIDY 40MM AP

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.

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Velocity Results : Adjusted

(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1632.074 | 0.00 | -204.519 | 0.1253 |
| 1 | 12.264 | 1629.568 | 20.00 | -204.111 | 0.1253 |
| 2 | 24.546 | 1627.063 | 40.00 | -203.701 | 0.1252 |
| 3 | 36.848 | 1624.560 | 60.00 | -203.291 | 0.1251 |
| 4 | 49.169 | 1622.058 | 80.00 | -202.881 | 0.1251 |
| 5 | 61.508 | 1619.557 | 100.00 | -202.469 | 0.1250 |
| 6 | 73.867 | 1617.058 | 120.00 | -202.057 | 0.1250 |
| 7 | 86.244 | 1614.560 | 140.00 | -201.645 | 0.1249 |
| 8 | 98.641 | 1612.063 | 160.00 | -201.231 | 0.1248 |
| 9 | 111.057 | 1609.567 | 180.00 | -200.818 | 0.1248 |
| 10 | 123.493 | 1607.073 | 200.00 | -200.403 | 0.1247 |
| 11 | 135.947 | 1604.580 | 220.00 | -199.988 | 0.1246 |
| 12 | 148.421 | 1602.088 | 240.00 | -199.572 | 0.1246 |
| 13 | 160.915 | 1599.598 | 260.00 | -199.156 | 0.1245 |
| 14 | 173.427 | 1597.109 | 280.00 | -198.738 | 0.1244 |
| 15 | 185.960 | 1594.621 | 300.00 | -198.321 | 0.1244 |
| 16 | 198.512 | 1592.135 | 320.00 | -197.902 | 0.1243 |
| 17 | 211.083 | 1589.650 | 340.00 | -197.483 | 0.1242 |
| 18 | 223.674 | 1587.167 | 360.00 | -197.063 | 0.1242 |
| 19 | 236.286 | 1584.685 | 380.00 | -196.643 | 0.1241 |
| 20 | 248.916 | 1582.205 | 400.00 | -196.222 | 0.1240 |
| 21 | 261.567 | 1579.726 | 420.00 | -195.800 | 0.1240 |
| 22 | 274.237 | 1577.248 | 440.00 | -195.378 | 0.1239 |
| 23 | 286.928 | 1574.773 | 460.00 | -194.955 | 0.1238 |
| 24 | 299.638 | 1572.298 | 480.00 | -194.531 | 0.1237 |
| 25 | 312.368 | 1569.825 | 500.00 | -194.106 | 0.1237 |
| 26 | 325.118 | 1567.354 | 520.00 | -193.681 | 0.1236 |
| 27 | 337.889 | 1564.884 | 540.00 | -193.256 | 0.1235 |
| 28 | 350.679 | 1562.416 | 560.00 | -192.829 | 0.1234 |
| 29 | 363.490 | 1559.949 | 580.00 | -192.402 | 0.1233 |
| 30 | 376.321 | 1557.484 | 600.00 | -191.974 | 0.1233 |
| 31 | 389.173 | 1555.021 | 620.00 | -191.546 | 0.1232 |
| 32 | 402.044 | 1552.560 | 640.00 | -191.116 | 0.1231 |
| 33 | 414.937 | 1550.100 | 660.00 | -190.687 | 0.1230 |
| 34 | 427.849 | 1547.641 | 680.00 | -190.256 | 0.1229 |
| 35 | 440.782 | 1545.185 | 700.00 | -189.825 | 0.1229 |
| 36 | 453.736 | 1542.730 | 720.00 | -189.393 | 0.1228 |
| 37 | 466.710 | 1540.277 | 740.00 | -188.960 | 0.1227 |
| 38 | 479.705 | 1537.825 | 760.00 | -188.523 | 0.1226 |

Table A-6. Velocity Data for the APFSDS Projectile, Shot No. 6

W E I B E L S C I E N T I F I C W-1000i #5037

| DATE | TIME | CHANNEL | ROUND |
|--------|--------------|---------|-------|
| 991027 | 11:43:07.297 | 1-4 | 6 |

B2 CASSIDY 40MM AP

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.

Velocity Results : Adjusted

(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1637.300 | 0.00 | -293.364 | 0.1792 |
| 1 | 12.229 | 1633.761 | 20.00 | -285.552 | 0.1748 |
| 2 | 24.483 | 1630.309 | 40.00 | -277.723 | 0.1704 |
| 3 | 36.764 | 1626.947 | 60.00 | -269.878 | 0.1659 |
| 4 | 49.069 | 1623.675 | 80.00 | -262.016 | 0.1614 |
| 5 | 61.399 | 1620.493 | 100.00 | -254.139 | 0.1568 |
| 6 | 73.753 | 1617.403 | 120.00 | -246.247 | 0.1523 |
| 7 | 86.130 | 1614.404 | 140.00 | -238.340 | 0.1476 |
| 8 | 98.529 | 1611.498 | 160.00 | -230.418 | 0.1430 |
| 9 | 110.951 | 1608.696 | 180.00 | -223.101 | 0.1387 |
| 10 | 123.394 | 1605.989 | 200.00 | -214.928 | 0.1338 |
| 11 | 135.858 | 1603.349 | 220.00 | -209.328 | 0.1306 |
| 12 | 148.342 | 1600.763 | 240.00 | -205.021 | 0.1281 |
| 13 | 160.846 | 1598.227 | 260.00 | -200.708 | 0.1256 |
| 14 | 173.369 | 1595.742 | 280.00 | -196.387 | 0.1231 |
| 15 | 185.912 | 1593.307 | 300.00 | -192.060 | 0.1205 |
| 16 | 198.517 | 1581.389 | 320.00 | -585.361 | 0.3702 |
| 17 | 211.194 | 1574.116 | 340.00 | -562.348 | 0.3573 |
| 18 | 223.928 | 1567.103 | 360.00 | -539.230 | 0.3441 |
| 19 | 236.718 | 1560.356 | 380.00 | -516.010 | 0.3307 |
| 20 | 249.562 | 1553.879 | 400.00 | -492.692 | 0.3171 |
| 21 | 262.459 | 1547.677 | 420.00 | -469.278 | 0.3032 |
| 22 | 275.406 | 1541.946 | 440.00 | -450.104 | 0.2919 |
| 23 | 288.400 | 1536.422 | 460.00 | -426.387 | 0.2775 |
| 24 | 301.440 | 1531.159 | 480.00 | -405.586 | 0.2649 |
| 25 | 314.524 | 1525.951 | 500.00 | -400.384 | 0.2624 |
| 26 | 327.654 | 1520.677 | 520.00 | -394.079 | 0.2592 |
| 27 | 340.829 | 1515.479 | 540.00 | -388.001 | 0.2560 |
| 28 | 354.047 | 1510.440 | 560.00 | -381.295 | 0.2524 |
| 29 | 367.310 | 1505.484 | 580.00 | -374.754 | 0.2489 |
| 30 | 380.617 | 1500.543 | 600.00 | -372.138 | 0.2480 |
| 31 | 393.968 | 1495.570 | 620.00 | -369.413 | 0.2470 |
| 32 | 407.363 | 1490.699 | 640.00 | -364.804 | 0.2447 |
| 33 | 420.801 | 1485.821 | 660.00 | -362.882 | 0.2442 |
| 34 | 434.284 | 1480.932 | 680.00 | -359.267 | 0.2426 |
| 35 | 447.811 | 1476.094 | 700.00 | -356.331 | 0.2414 |
| 36 | 461.383 | 1471.280 | 720.00 | -353.382 | 0.2402 |
| 37 | 474.998 | 1466.491 | 740.00 | -350.421 | 0.2390 |
| 38 | 488.659 | 1461.727 | 760.00 | -347.450 | 0.2377 |

Table A-7. Velocity Data for the APFSDS Projectile, Shot No. 7

WEIBEL SCIENTIFIC W-1000i #5037

DATE TIME CHANNEL ROUND
991027 12:17:59.681 1-4 7
B2 CASSIDY 40MM AP
VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.
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Velocity Results : Adjusted
(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1640.004 | 0.00 | -188.284 | 0.1148 |
| 1 | 12.204 | 1637.701 | 20.00 | -189.116 | 0.1155 |
| 2 | 24.425 | 1635.385 | 40.00 | -189.949 | 0.1162 |
| 3 | 36.663 | 1633.055 | 60.00 | -190.783 | 0.1168 |
| 4 | 48.919 | 1630.712 | 80.00 | -191.618 | 0.1175 |
| 5 | 61.192 | 1628.355 | 100.00 | -192.454 | 0.1182 |
| 6 | 73.483 | 1625.985 | 120.00 | -193.292 | 0.1189 |
| 7 | 85.793 | 1623.600 | 140.00 | -194.131 | 0.1196 |
| 8 | 98.120 | 1621.143 | 160.00 | -196.860 | 0.1214 |
| 9 | 110.466 | 1618.756 | 180.00 | -196.483 | 0.1214 |
| 10 | 122.830 | 1616.361 | 200.00 | -195.969 | 0.1212 |
| 11 | 135.213 | 1613.915 | 220.00 | -200.621 | 0.1243 |
| 12 | 147.615 | 1611.407 | 240.00 | -197.311 | 0.1225 |
| 13 | 160.036 | 1608.927 | 260.00 | -199.056 | 0.1237 |
| 14 | 172.476 | 1606.435 | 280.00 | -197.628 | 0.1230 |
| 15 | 184.936 | 1603.986 | 300.00 | -197.107 | 0.1229 |
| 16 | 197.414 | 1601.559 | 320.00 | -195.873 | 0.1223 |
| 17 | 209.912 | 1599.071 | 340.00 | -195.450 | 0.1222 |
| 18 | 222.428 | 1596.680 | 360.00 | -196.747 | 0.1232 |
| 19 | 234.964 | 1594.214 | 380.00 | -196.231 | 0.1231 |
| 20 | 247.519 | 1591.789 | 400.00 | -194.993 | 0.1225 |
| 21 | 260.094 | 1589.294 | 420.00 | -195.796 | 0.1232 |
| 22 | 272.688 | 1586.770 | 440.00 | -195.699 | 0.1233 |
| 23 | 285.302 | 1584.349 | 460.00 | -194.848 | 0.1230 |
| 24 | 297.935 | 1581.825 | 480.00 | -194.335 | 0.1229 |
| 25 | 310.588 | 1579.408 | 500.00 | -194.120 | 0.1229 |
| 26 | 323.261 | 1576.982 | 520.00 | -191.054 | 0.1212 |
| 27 | 335.953 | 1574.573 | 540.00 | -194.439 | 0.1235 |
| 28 | 348.665 | 1572.122 | 560.00 | -197.310 | 0.1255 |
| 29 | 361.397 | 1569.581 | 580.00 | -197.745 | 0.1260 |
| 30 | 374.150 | 1566.951 | 600.00 | -197.075 | 0.1258 |
| 31 | 386.924 | 1564.422 | 620.00 | -194.364 | 0.1242 |
| 32 | 399.718 | 1561.904 | 640.00 | -192.918 | 0.1235 |
| 33 | 412.533 | 1559.471 | 660.00 | -189.927 | 0.1218 |
| 34 | 425.368 | 1557.060 | 680.00 | -189.747 | 0.1219 |
| 35 | 438.222 | 1554.780 | 700.00 | -185.440 | 0.1193 |
| 36 | 451.096 | 1552.405 | 720.00 | -184.658 | 0.1190 |
| 37 | 463.989 | 1549.977 | 740.00 | -187.798 | 0.1212 |
| 38 | 476.902 | 1547.506 | 760.00 | -189.745 | 0.1226 |
| 39 | 489.836 | 1545.103 | 780.00 | -194.213 | 0.1257 |
| 40 | 502.791 | 1542.525 | 800.00 | -193.100 | 0.1252 |
| 41 | 515.768 | 1540.021 | 820.00 | -194.255 | 0.1261 |
| 42 | 528.765 | 1537.457 | 840.00 | -192.449 | 0.1252 |

| | | | | | |
|----|---------|----------|--------|----------|--------|
| 43 | 541.785 | 1534.957 | 860.00 | -191.696 | 0.1249 |
| 44 | 554.825 | 1532.463 | 880.00 | -190.943 | 0.1246 |
| 45 | 567.886 | 1529.975 | 900.00 | -190.188 | 0.1243 |
| 46 | 580.969 | 1527.492 | 920.00 | -189.433 | 0.1240 |
| 47 | 594.073 | 1525.016 | 940.00 | -188.676 | 0.1237 |
| 48 | 607.198 | 1522.546 | 960.00 | -187.915 | 0.1234 |

Table A-8. Velocity Data for the APFSDS Projectile, Shot No. 8
(elevated)

W E I B E L S C I E N T I F I C W-1000i #5037

DATE TIME CHANNEL ROUND
991027 14:32:06.617 1-4 8

B2 CASSIDY 40MM AP

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.

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Velocity Results : Adjusted
(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1639.096 | 0.00 | -209.588 | 0.1279 |
| 1 | 61.248 | 1626.387 | 100.00 | -205.418 | 0.1263 |
| 2 | 122.972 | 1613.837 | 200.00 | -201.214 | 0.1247 |
| 3 | 185.176 | 1601.453 | 300.00 | -196.979 | 0.1230 |
| 4 | 247.859 | 1589.304 | 400.00 | -192.683 | 0.1212 |
| 5 | 311.020 | 1577.211 | 500.00 | -189.885 | 0.1204 |
| 6 | 374.665 | 1565.279 | 600.00 | -186.963 | 0.1194 |
| 7 | 438.796 | 1553.357 | 700.00 | -184.844 | 0.1190 |
| 8 | 503.420 | 1541.471 | 800.00 | -182.241 | 0.1182 |
| 9 | 568.543 | 1529.679 | 900.00 | -180.140 | 0.1178 |
| 10 | 634.168 | 1517.942 | 1000.00 | -177.947 | 0.1172 |
| 11 | 700.302 | 1506.254 | 1100.00 | -176.168 | 0.1170 |
| 12 | 766.951 | 1494.582 | 1200.00 | -174.677 | 0.1169 |
| 13 | 834.121 | 1482.904 | 1300.00 | -173.472 | 0.1170 |
| 14 | 901.824 | 1471.196 | 1400.00 | -172.540 | 0.1173 |
| 15 | 970.069 | 1459.424 | 1500.00 | -170.984 | 0.1172 |
| 16 | 1038.866 | 1447.692 | 1600.00 | -168.770 | 0.1166 |
| 17 | 1108.221 | 1436.094 | 1700.00 | -166.392 | 0.1159 |
| 18 | 1178.134 | 1424.589 | 1800.00 | -164.829 | 0.1157 |
| 19 | 1248.615 | 1413.057 | 1900.00 | -163.350 | 0.1156 |
| 20 | 1319.676 | 1401.491 | 2000.00 | -162.146 | 0.1157 |
| 21 | 1391.325 | 1389.889 | 2100.00 | -161.352 | 0.1161 |
| 22 | 1463.575 | 1378.310 | 2200.00 | -159.924 | 0.1160 |
| 23 | 1536.435 | 1366.685 | 2300.00 | -159.153 | 0.1165 |
| 24 | 1609.919 | 1355.017 | 2400.00 | -158.387 | 0.1169 |
| 25 | 1684.040 | 1343.315 | 2500.00 | -157.179 | 0.1170 |
| 26 | 1758.810 | 1331.590 | 2600.00 | -156.388 | 0.1174 |
| 27 | 1834.241 | 1319.844 | 2700.00 | -155.610 | 0.1179 |
| 28 | 1910.349 | 1308.030 | 2800.00 | -154.988 | 0.1185 |
| 29 | 1987.150 | 1296.123 | 2900.00 | -154.290 | 0.1190 |
| 30 | 2064.660 | 1284.203 | 3000.00 | -152.954 | 0.1191 |
| 31 | 2142.893 | 1272.291 | 3100.00 | -151.473 | 0.1191 |
| 32 | 2221.861 | 1260.404 | 3200.00 | -150.078 | 0.1191 |
| 33 | 2301.578 | 1248.491 | 3300.00 | -148.724 | 0.1191 |
| 34 | 2382.058 | 1236.575 | 3400.00 | -147.286 | 0.1191 |
| 35 | 2463.318 | 1224.665 | 3500.00 | -145.891 | 0.1191 |
| 36 | 2545.373 | 1212.762 | 3600.00 | -144.316 | 0.1190 |
| 37 | 2628.237 | 1200.860 | 3700.00 | -142.965 | 0.1191 |
| 38 | 2711.925 | 1188.973 | 3800.00 | -141.537 | 0.1190 |
| 39 | 2796.456 | 1177.061 | 3900.00 | -139.973 | 0.1189 |
| 40 | 2881.845 | 1165.189 | 4000.00 | -138.506 | 0.1189 |
| 41 | 2968.109 | 1153.317 | 4100.00 | -137.008 | 0.1188 |

| | | | | | |
|----|----------|----------|---------|----------|--------|
| 42 | 3055.264 | 1141.381 | 4200.00 | -135.838 | 0.1190 |
| 43 | 3143.338 | 1129.486 | 4300.00 | -134.094 | 0.1187 |
| 44 | 3232.340 | 1117.649 | 4400.00 | -132.459 | 0.1185 |
| 45 | 3322.288 | 1105.875 | 4500.00 | -130.748 | 0.1182 |
| 46 | 3413.203 | 1093.962 | 4600.00 | -129.780 | 0.1186 |
| 47 | 3505.112 | 1082.132 | 4700.00 | -128.416 | 0.1187 |
| 48 | 3598.034 | 1070.268 | 4800.00 | -126.631 | 0.1183 |
| 49 | 3691.989 | 1058.456 | 4900.00 | -124.910 | 0.1180 |

Table A-9. Velocity Data for the APFSDS Projectile, Shot No. 9
(elevated)

W E I B E L S C I E N T I F I C W-1000i #5037

DATE TIME CHANNEL ROUND
991027 14:41:35.239 1-4 9

B2 CASSIDY 40MM AP

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.

=====

Velocity Results : Adjusted
(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1638.931 | 0.00 | -217.425 | 0.1327 |
| 1 | 61.262 | 1625.781 | 100.00 | -211.857 | 0.1303 |
| 2 | 123.018 | 1612.872 | 200.00 | -206.244 | 0.1279 |
| 3 | 185.264 | 1600.210 | 300.00 | -200.586 | 0.1254 |
| 4 | 248.000 | 1587.805 | 400.00 | -194.884 | 0.1227 |
| 5 | 311.222 | 1575.836 | 500.00 | -189.086 | 0.1200 |
| 6 | 374.917 | 1564.115 | 600.00 | -185.901 | 0.1189 |
| 7 | 439.092 | 1552.360 | 700.00 | -184.470 | 0.1188 |
| 8 | 503.757 | 1540.473 | 800.00 | -183.811 | 0.1193 |
| 9 | 568.926 | 1528.491 | 900.00 | -183.201 | 0.1199 |
| 10 | 634.609 | 1516.436 | 1000.00 | -182.273 | 0.1202 |
| 11 | 700.818 | 1504.359 | 1100.00 | -180.991 | 0.1203 |
| 12 | 767.558 | 1492.318 | 1200.00 | -179.284 | 0.1201 |
| 13 | 834.839 | 1480.327 | 1300.00 | -177.402 | 0.1198 |
| 14 | 902.667 | 1468.355 | 1400.00 | -175.613 | 0.1196 |
| 15 | 971.048 | 1456.416 | 1500.00 | -173.769 | 0.1193 |
| 16 | 1039.993 | 1444.499 | 1600.00 | -171.995 | 0.1191 |
| 17 | 1109.507 | 1432.624 | 1700.00 | -170.310 | 0.1189 |
| 18 | 1179.599 | 1420.755 | 1800.00 | -168.732 | 0.1188 |
| 19 | 1250.280 | 1408.889 | 1900.00 | -167.240 | 0.1187 |
| 20 | 1321.559 | 1397.025 | 2000.00 | -165.724 | 0.1186 |
| 21 | 1393.445 | 1385.184 | 2100.00 | -164.571 | 0.1188 |
| 22 | 1465.949 | 1373.310 | 2200.00 | -163.441 | 0.1190 |
| 23 | 1539.083 | 1361.398 | 2300.00 | -162.281 | 0.1192 |
| 24 | 1612.861 | 1349.460 | 2400.00 | -161.064 | 0.1194 |
| 25 | 1687.295 | 1337.506 | 2500.00 | -159.811 | 0.1195 |
| 26 | 1762.397 | 1325.543 | 2600.00 | -158.410 | 0.1195 |
| 27 | 1838.179 | 1313.618 | 2700.00 | -156.875 | 0.1194 |
| 28 | 1914.653 | 1301.679 | 2800.00 | -155.513 | 0.1195 |
| 29 | 1991.831 | 1289.732 | 2900.00 | -154.144 | 0.1195 |
| 30 | 2069.728 | 1277.782 | 3000.00 | -152.739 | 0.1195 |
| 31 | 2148.357 | 1265.835 | 3100.00 | -151.347 | 0.1196 |
| 32 | 2227.733 | 1253.876 | 3200.00 | -149.943 | 0.1196 |
| 33 | 2307.869 | 1241.920 | 3300.00 | -148.493 | 0.1196 |
| 34 | 2388.779 | 1229.968 | 3400.00 | -147.049 | 0.1196 |
| 35 | 2470.480 | 1218.019 | 3500.00 | -145.612 | 0.1196 |
| 36 | 2552.985 | 1206.076 | 3600.00 | -144.204 | 0.1196 |
| 37 | 2636.312 | 1194.123 | 3700.00 | -142.852 | 0.1196 |
| 38 | 2720.478 | 1182.157 | 3800.00 | -141.508 | 0.1197 |
| 39 | 2805.500 | 1170.189 | 3900.00 | -140.116 | 0.1197 |
| 40 | 2891.397 | 1158.214 | 4000.00 | -138.714 | 0.1198 |
| 41 | 2978.186 | 1146.237 | 4100.00 | -137.272 | 0.1198 |

| | | | | | |
|----|----------|----------|---------|----------|--------|
| 42 | 3065.888 | 1134.264 | 4200.00 | -135.795 | 0.1197 |
| 43 | 3154.519 | 1122.299 | 4300.00 | -134.312 | 0.1197 |
| 44 | 3244.100 | 1110.346 | 4400.00 | -132.837 | 0.1196 |
| 45 | 3334.650 | 1098.400 | 4500.00 | -131.404 | 0.1196 |
| 46 | 3426.191 | 1086.432 | 4600.00 | -130.009 | 0.1197 |
| 47 | 3518.745 | 1074.468 | 4700.00 | -128.478 | 0.1196 |
| 48 | 3612.337 | 1062.515 | 4800.00 | -126.867 | 0.1194 |
| 49 | 3706.986 | 1050.582 | 4900.00 | -125.048 | 0.1190 |
| 50 | 3802.714 | 1038.715 | 5000.00 | -123.150 | 0.1186 |
| 51 | 3899.540 | 1026.898 | 5100.00 | -121.252 | 0.1181 |
| 52 | 3997.485 | 1015.111 | 5200.00 | -119.273 | 0.1175 |
| 53 | 4096.570 | 1003.391 | 5300.00 | -117.148 | 0.1168 |
| 54 | 4196.815 | 991.763 | 5400.00 | -115.074 | 0.1160 |
| 55 | 4298.236 | 980.233 | 5500.00 | -113.133 | 0.1154 |
| 56 | 4400.855 | 968.745 | 5600.00 | -111.685 | 0.1153 |
| 57 | 4504.698 | 957.235 | 5700.00 | -110.888 | 0.1158 |
| 58 | 4609.804 | 945.629 | 5800.00 | -110.424 | 0.1168 |
| 59 | 4716.216 | 933.886 | 5900.00 | -109.789 | 0.1176 |
| 60 | 4823.977 | 922.099 | 6000.00 | -109.119 | 0.1183 |
| 61 | 4933.128 | 910.233 | 6100.00 | -108.440 | 0.1191 |

Table A-10. Velocity Data for the APFSDS Projectile, Shot No. 10
(elevated)

DATA MISSING

Table A-11. Velocity Data for the GP Projectile, Shot No. 11
(BURST MODE 11-1)

W E I B E L S C I E N T I F I C W-1000i #5030

DATE TIME CHANNEL ROUND
991027 15:43:03.493 1-4 11

B2 CASSIDY 40MM GPI BURST

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.

=====

Velocity Results : Adjusted

(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1035.347 | 0.00 | -786.170 | 0.7593 |
| 1 | 19.460 | 1020.222 | 20.00 | -768.307 | 0.7531 |
| 2 | 39.209 | 1005.228 | 40.00 | -750.179 | 0.7463 |
| 3 | 59.253 | 990.376 | 60.00 | -731.779 | 0.7389 |
| 4 | 79.600 | 975.677 | 80.00 | -713.102 | 0.7309 |
| 5 | 100.253 | 961.145 | 100.00 | -694.143 | 0.7222 |
| 6 | 121.219 | 946.793 | 120.00 | -674.898 | 0.7128 |
| 7 | 142.503 | 932.588 | 140.00 | -656.222 | 0.7037 |
| 8 | 164.113 | 918.511 | 160.00 | -637.913 | 0.6945 |
| 9 | 186.050 | 904.963 | 180.00 | -615.767 | 0.6804 |
| 10 | 208.316 | 891.556 | 200.00 | -596.736 | 0.6693 |
| 11 | 230.917 | 878.337 | 220.00 | -579.898 | 0.6602 |
| 12 | 253.859 | 865.266 | 240.00 | -563.232 | 0.6509 |
| 13 | 277.147 | 852.356 | 260.00 | -546.389 | 0.6410 |
| 14 | 300.789 | 839.632 | 280.00 | -529.521 | 0.6307 |
| 15 | 324.789 | 827.119 | 300.00 | -512.504 | 0.6196 |
| 16 | 349.151 | 814.846 | 320.00 | -495.586 | 0.6082 |
| 17 | 373.879 | 802.812 | 340.00 | -478.893 | 0.5965 |
| 18 | 398.977 | 791.051 | 360.00 | -462.494 | 0.5847 |
| 19 | 424.446 | 779.555 | 380.00 | -446.495 | 0.5728 |
| 20 | 450.288 | 768.294 | 400.00 | -431.908 | 0.5622 |
| 21 | 476.510 | 757.196 | 420.00 | -418.828 | 0.5531 |
| 22 | 503.116 | 746.265 | 440.00 | -406.533 | 0.5448 |
| 23 | 530.112 | 735.491 | 460.00 | -394.908 | 0.5369 |
| 24 | 557.504 | 724.863 | 480.00 | -383.946 | 0.5297 |
| 25 | 585.298 | 714.361 | 500.00 | -373.700 | 0.5231 |
| 26 | 613.501 | 703.983 | 520.00 | -363.556 | 0.5164 |
| 27 | 642.120 | 693.741 | 540.00 | -354.040 | 0.5103 |
| 28 | 671.161 | 683.636 | 560.00 | -345.099 | 0.5048 |
| 29 | 700.633 | 673.641 | 580.00 | -337.296 | 0.5007 |
| 30 | 730.543 | 663.723 | 600.00 | -331.063 | 0.4988 |
| 31 | 760.905 | 653.762 | 620.00 | -325.185 | 0.4974 |
| 32 | 791.732 | 643.831 | 640.00 | -319.217 | 0.4958 |
| 33 | 823.038 | 633.934 | 660.00 | -313.156 | 0.4940 |
| 34 | 854.835 | 624.076 | 680.00 | -306.999 | 0.4919 |
| 35 | 887.137 | 614.262 | 700.00 | -300.743 | 0.4896 |

Table A-12. Velocity Data for the GP Projectile, Shot No. 12
(BURST MODE #11-2)

W E I B E L S C I E N T I F I C W-1000i #5030

DATE TIME CHANNEL ROUND
991027 15:43:03.493 1-4 12

B2 CASSIDY 40MM GPI BURST

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.
=====

Time Offset : 1060.000 ms.

Velocity Results : Adjusted

(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1041.321 | 0.00 | -800.520 | 0.7688 |
| 1 | 19.349 | 1026.025 | 20.00 | -780.519 | 0.7607 |
| 2 | 38.987 | 1010.897 | 40.00 | -760.220 | 0.7520 |
| 3 | 58.919 | 995.949 | 60.00 | -739.617 | 0.7426 |
| 4 | 79.152 | 981.197 | 80.00 | -718.703 | 0.7325 |
| 5 | 99.688 | 966.655 | 100.00 | -697.476 | 0.7215 |
| 6 | 120.533 | 952.341 | 120.00 | -675.929 | 0.7098 |
| 7 | 141.691 | 938.289 | 140.00 | -653.976 | 0.6970 |
| 8 | 163.164 | 924.601 | 160.00 | -632.984 | 0.6846 |
| 9 | 184.954 | 911.137 | 180.00 | -613.846 | 0.6737 |
| 10 | 207.067 | 897.809 | 200.00 | -596.179 | 0.6640 |
| 11 | 229.509 | 884.653 | 220.00 | -581.989 | 0.6579 |
| 12 | 252.285 | 871.641 | 240.00 | -566.134 | 0.6495 |
| 13 | 275.402 | 858.771 | 260.00 | -551.255 | 0.6419 |
| 14 | 298.865 | 846.025 | 280.00 | -536.719 | 0.6344 |
| 15 | 322.683 | 833.405 | 300.00 | -522.738 | 0.6272 |
| 16 | 346.863 | 820.927 | 320.00 | -508.914 | 0.6199 |
| 17 | 371.411 | 808.614 | 340.00 | -494.962 | 0.6121 |
| 18 | 396.332 | 796.473 | 360.00 | -480.920 | 0.6038 |
| 19 | 421.633 | 784.589 | 380.00 | -466.039 | 0.5940 |
| 20 | 447.319 | 772.743 | 400.00 | -453.666 | 0.5871 |
| 21 | 473.399 | 761.077 | 420.00 | -440.554 | 0.5789 |
| 22 | 499.878 | 749.604 | 440.00 | -427.263 | 0.5700 |
| 23 | 526.762 | 738.315 | 460.00 | -414.347 | 0.5612 |
| 24 | 554.058 | 727.207 | 480.00 | -401.816 | 0.5526 |
| 25 | 581.770 | 716.249 | 500.00 | -389.319 | 0.5436 |
| 26 | 609.906 | 705.483 | 520.00 | -376.773 | 0.5341 |
| 27 | 638.471 | 694.907 | 540.00 | -364.829 | 0.5250 |
| 28 | 667.470 | 684.520 | 560.00 | -353.158 | 0.5159 |
| 29 | 696.908 | 674.331 | 580.00 | -341.941 | 0.5071 |
| 30 | 726.789 | 664.397 | 600.00 | -334.214 | 0.5030 |
| 31 | 757.121 | 654.364 | 620.00 | -327.402 | 0.5003 |
| 32 | 787.921 | 644.388 | 640.00 | -320.484 | 0.4974 |
| 33 | 819.199 | 634.475 | 660.00 | -313.459 | 0.4940 |

Table A-13. Velocity Data for the GP Projectile, Shot No. 13
(BURST MODE 11-3)

W E I B E L S C I E N T I F I C W-1000i #5030

| DATE | TIME | CHANNEL | ROUND |
|--------|--------------|---------|-------|
| 991027 | 15:43:03.493 | 1-4 | 13 |

B2 CASSIDY 40MM GPI BURST

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.

Time Offset : 2128.000 ms.

Velocity Results : Adjusted

(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1037.665 | 0.00 | -852.398 | 0.8215 |
| 1 | 19.428 | 1021.369 | 20.00 | -825.174 | 0.8079 |
| 2 | 39.164 | 1005.356 | 40.00 | -797.517 | 0.7933 |
| 3 | 59.215 | 989.647 | 60.00 | -769.421 | 0.7775 |
| 4 | 79.584 | 974.265 | 80.00 | -740.878 | 0.7605 |
| 5 | 100.273 | 959.237 | 100.00 | -711.887 | 0.7421 |
| 6 | 121.285 | 944.589 | 120.00 | -682.445 | 0.7225 |
| 7 | 142.619 | 930.629 | 140.00 | -650.276 | 0.6988 |
| 8 | 164.268 | 917.101 | 160.00 | -625.524 | 0.6821 |
| 9 | 186.237 | 903.720 | 180.00 | -605.465 | 0.6700 |
| 10 | 208.532 | 890.497 | 200.00 | -587.306 | 0.6595 |
| 11 | 231.159 | 877.388 | 220.00 | -571.571 | 0.6515 |
| 12 | 254.123 | 864.515 | 240.00 | -556.168 | 0.6433 |
| 13 | 277.430 | 851.764 | 260.00 | -540.642 | 0.6347 |
| 14 | 301.087 | 839.160 | 280.00 | -525.248 | 0.6259 |
| 15 | 325.099 | 826.722 | 300.00 | -509.367 | 0.6161 |
| 16 | 349.472 | 814.481 | 320.00 | -493.696 | 0.6062 |
| 17 | 374.211 | 802.465 | 340.00 | -478.262 | 0.5960 |
| 18 | 399.320 | 790.688 | 360.00 | -462.967 | 0.5855 |
| 19 | 424.801 | 779.174 | 380.00 | -448.068 | 0.5751 |
| 20 | 450.657 | 767.874 | 400.00 | -434.614 | 0.5660 |
| 21 | 476.895 | 756.665 | 420.00 | -423.003 | 0.5590 |
| 22 | 503.522 | 745.579 | 440.00 | -412.333 | 0.5530 |
| 23 | 530.547 | 734.611 | 460.00 | -402.123 | 0.5474 |
| 24 | 557.977 | 723.720 | 480.00 | -391.960 | 0.5416 |
| 25 | 585.820 | 712.940 | 500.00 | -381.557 | 0.5352 |
| 26 | 614.085 | 702.287 | 520.00 | -370.838 | 0.5280 |
| 27 | 642.779 | 691.797 | 540.00 | -360.005 | 0.5204 |
| 28 | 671.907 | 681.475 | 560.00 | -348.989 | 0.5121 |
| 29 | 701.474 | 671.396 | 580.00 | -340.371 | 0.5070 |
| 30 | 731.489 | 661.310 | 600.00 | -331.828 | 0.5018 |
| 31 | 761.963 | 651.331 | 620.00 | -323.154 | 0.4961 |
| 32 | 792.905 | 641.470 | 640.00 | -314.346 | 0.4900 |
| 33 | 824.323 | 631.735 | 660.00 | -305.403 | 0.4834 |
| 34 | 856.225 | 622.139 | 680.00 | -296.321 | 0.4763 |

Table A-14. Velocity Data for the GP Projectile, Shot No. 14
(BURST MODE 12-1)

W E I B E L S C I E N T I F I C W-1000i #5030

DATE TIME CHANNEL ROUND
991027 16:04:51.115 1-4 14

B2 CASSIDY 40MM GPI BURST

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.

=====

Velocity Results : Adjusted

(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1037.955 | 0.00 | -809.709 | 0.7801 |
| 1 | 19.414 | 1022.463 | 20.00 | -786.262 | 0.7690 |
| 2 | 39.123 | 1007.201 | 40.00 | -762.461 | 0.7570 |
| 3 | 59.129 | 992.189 | 60.00 | -738.299 | 0.7441 |
| 4 | 79.439 | 977.444 | 80.00 | -713.771 | 0.7302 |
| 5 | 100.054 | 962.986 | 100.00 | -688.874 | 0.7154 |
| 6 | 120.976 | 948.980 | 120.00 | -666.187 | 0.7020 |
| 7 | 142.204 | 935.363 | 140.00 | -643.289 | 0.6877 |
| 8 | 163.744 | 921.457 | 160.00 | -633.362 | 0.6874 |
| 9 | 185.612 | 907.817 | 180.00 | -614.353 | 0.6767 |
| 10 | 207.808 | 894.365 | 200.00 | -595.078 | 0.6654 |
| 11 | 230.337 | 881.238 | 220.00 | -574.599 | 0.6520 |
| 12 | 253.201 | 868.356 | 240.00 | -557.245 | 0.6417 |
| 13 | 276.403 | 855.715 | 260.00 | -542.513 | 0.6340 |
| 14 | 299.949 | 843.106 | 280.00 | -526.347 | 0.6243 |
| 15 | 323.848 | 830.673 | 300.00 | -510.932 | 0.6151 |
| 16 | 348.104 | 818.444 | 320.00 | -495.946 | 0.6060 |
| 17 | 372.722 | 806.460 | 340.00 | -480.309 | 0.5956 |
| 18 | 397.705 | 794.730 | 360.00 | -464.841 | 0.5849 |
| 19 | 423.054 | 783.185 | 380.00 | -451.827 | 0.5769 |
| 20 | 448.780 | 771.715 | 400.00 | -440.015 | 0.5702 |
| 21 | 474.889 | 760.385 | 420.00 | -428.027 | 0.5629 |
| 22 | 501.387 | 749.206 | 440.00 | -415.860 | 0.5551 |

Table A-15. Velocity Data for the GP Projectile, Shot No. 15
(BURST MODE 12-2)

W E I B E L S C I E N T I F I C W-1000i #5030

DATE TIME CHANNEL ROUND
991027 16:04:51.115 1-4 15

B2 CASSIDY 40MM GPI BURST

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.
=====

Time Offset : 425.000 ms.

Velocity Results : Adjusted

(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1044.489 | 0.00 | -820.759 | 0.7858 |
| 1 | 19.293 | 1028.876 | 20.00 | -797.773 | 0.7754 |
| 2 | 38.879 | 1013.480 | 40.00 | -774.438 | 0.7641 |
| 3 | 58.762 | 998.317 | 60.00 | -750.749 | 0.7520 |
| 4 | 78.948 | 983.405 | 80.00 | -726.698 | 0.7390 |
| 5 | 99.439 | 968.765 | 100.00 | -702.285 | 0.7249 |
| 6 | 120.238 | 954.494 | 120.00 | -677.444 | 0.7097 |
| 7 | 141.347 | 940.516 | 140.00 | -655.936 | 0.6974 |
| 8 | 162.769 | 926.747 | 160.00 | -636.234 | 0.6865 |
| 9 | 184.510 | 913.130 | 180.00 | -618.018 | 0.6768 |
| 10 | 206.576 | 899.690 | 200.00 | -600.295 | 0.6672 |
| 11 | 228.971 | 886.486 | 220.00 | -582.152 | 0.6567 |
| 12 | 251.700 | 873.474 | 240.00 | -565.445 | 0.6474 |
| 13 | 274.766 | 860.672 | 260.00 | -550.660 | 0.6398 |
| 14 | 298.178 | 847.950 | 280.00 | -534.962 | 0.6309 |
| 15 | 321.941 | 835.393 | 300.00 | -518.438 | 0.6206 |
| 16 | 346.061 | 823.055 | 320.00 | -501.491 | 0.6093 |
| 17 | 370.541 | 810.983 | 340.00 | -484.147 | 0.5970 |
| 18 | 395.383 | 799.265 | 360.00 | -466.900 | 0.5842 |
| 19 | 420.588 | 787.748 | 380.00 | -452.105 | 0.5739 |
| 20 | 446.162 | 776.377 | 400.00 | -438.527 | 0.5648 |
| 21 | 472.111 | 765.173 | 420.00 | -425.120 | 0.5556 |
| 22 | 498.439 | 754.160 | 440.00 | -411.515 | 0.5457 |

Table A-16. Velocity Data for the GP Projectile, Shot No. 16
(BURST MODE 12-3)

W E I B E L S C I E N T I F I C W-1000i #5030

| | | | |
|--------|--------------|---------|-------|
| DATE | TIME | CHANNEL | ROUND |
| 991027 | 16:04:51.115 | 1-4 | 16 |

B2 CASSIDY 40MM GPI BURST

VELOCITY VERSUS TIME and RESULTS BASED ON REGRESSION ANALYSIS.

Time Offset : 1080.000 ms.

Velocity Results : Adjusted

(Based on sliding fits)

| NO | TIME ms. | VELOCITY m/s. | DISTANCE m | ACCL. m/s/s | RETARD. m/s/m |
|------|-------------|------------------|---------------|----------------|------------------|
| Muzz | 0.000 | 1041.635 | 0.00 | -812.103 | 0.7796 |
| 1 | 19.345 | 1026.124 | 20.00 | -791.593 | 0.7714 |
| 2 | 38.983 | 1010.783 | 40.00 | -770.773 | 0.7626 |
| 3 | 58.920 | 995.627 | 60.00 | -749.637 | 0.7529 |
| 4 | 79.161 | 980.671 | 80.00 | -728.177 | 0.7425 |
| 5 | 99.710 | 965.931 | 100.00 | -706.391 | 0.7313 |
| 6 | 120.574 | 951.371 | 120.00 | -685.477 | 0.7205 |
| 7 | 141.755 | 937.146 | 140.00 | -662.269 | 0.7067 |
| 8 | 163.257 | 923.189 | 160.00 | -641.000 | 0.6943 |
| 9 | 185.084 | 909.489 | 180.00 | -620.357 | 0.6821 |
| 10 | 207.239 | 896.027 | 200.00 | -600.808 | 0.6705 |
| 11 | 229.727 | 882.748 | 220.00 | -582.676 | 0.6601 |
| 12 | 252.553 | 869.681 | 240.00 | -565.207 | 0.6499 |
| 13 | 275.722 | 856.823 | 260.00 | -549.750 | 0.6416 |
| 14 | 299.240 | 844.063 | 280.00 | -533.133 | 0.6316 |
| 15 | 323.113 | 831.517 | 300.00 | -515.441 | 0.6199 |
| 16 | 347.346 | 819.219 | 320.00 | -497.850 | 0.6077 |
| 17 | 371.941 | 807.218 | 340.00 | -480.972 | 0.5958 |
| 18 | 396.900 | 795.506 | 360.00 | -464.283 | 0.5836 |
| 19 | 422.224 | 784.028 | 380.00 | -450.239 | 0.5743 |
| 20 | 447.921 | 772.612 | 400.00 | -437.867 | 0.5667 |
| 21 | 473.998 | 761.354 | 420.00 | -425.636 | 0.5591 |
| 22 | 500.461 | 750.256 | 440.00 | -413.224 | 0.5508 |

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APPENDIX B
INDIVIDUAL OVERPRESSURE PLOTS

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BRADLEY 40-LIM CUM FIRE TEST
 ROUND 1 26 OCTOBER 1999
 CHANNEL 1 OVERPRESSURE, DRIVER

LPF(H): 40000 Hz

GAGE ID: PCB 10114 / S114331
 GAGE FACTOR: 105.1 MPa/V
 SYSTEM GAIN: 150

Max: .895
 Min: -.672

A-duration: 2.8 msec
 B-duration: 139.4 msec
 Max. pressure: 10563.1
 w. single heating protector

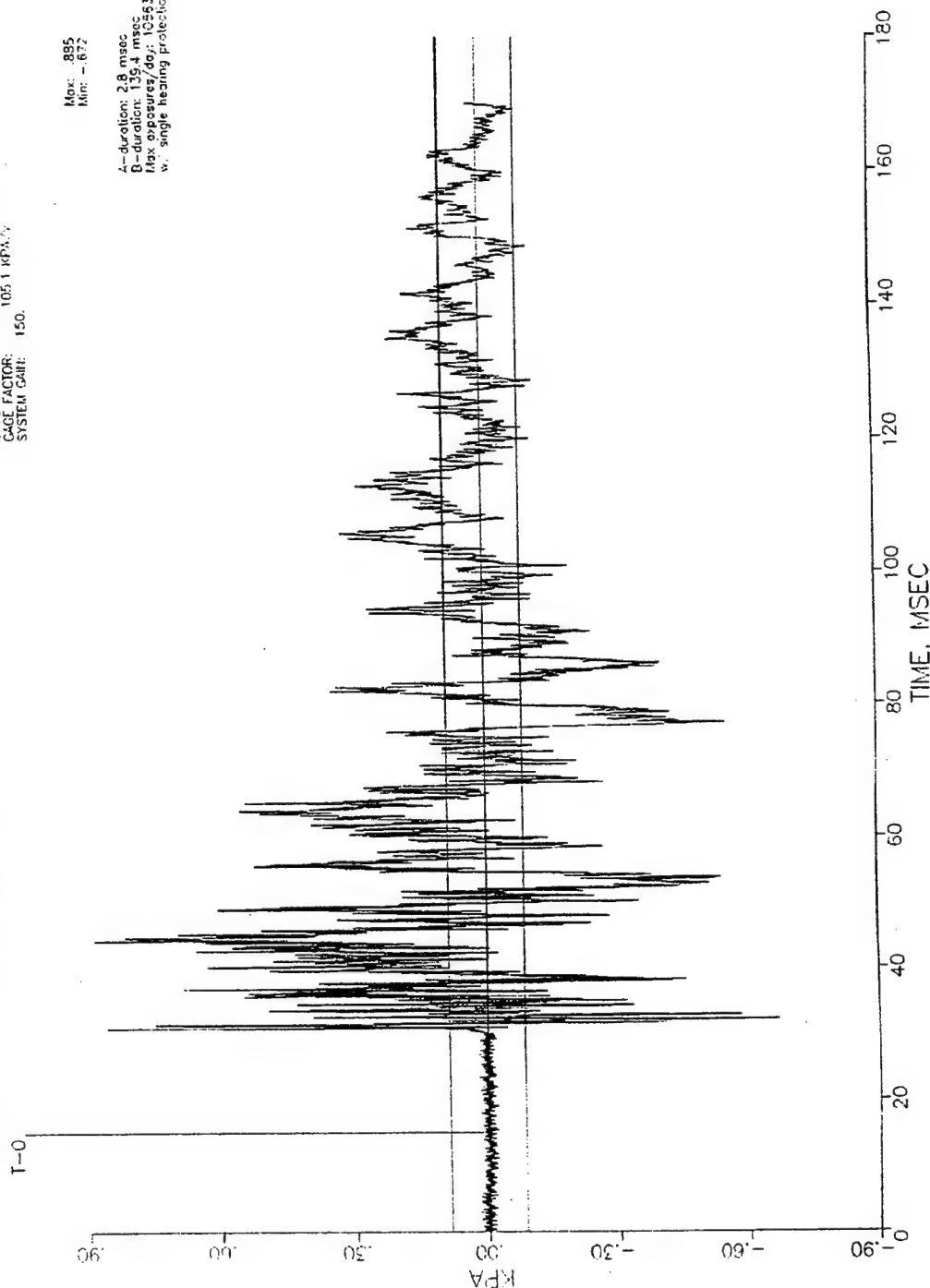


Figure B-1. Overpressure Plot for Shot 1 at the Driver Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 1 26 OCTOBER 1999
 CHANNEL 2 OVERPRESSURE, TURRET LEFT

LFF(A): 40000 HZ

GAGE ID: PCB 1014 /SN 4333
 GAGE FACTOR: 112.6 MPa/V
 SYSTEM GAIN: 150.

Max: 2.4
 Min: -2.2

A - Duration: 2.3 msec
 B - Duration: 125.1 msec
 Ms - Pressure/dy: 2185
 W - Single Reading Protection

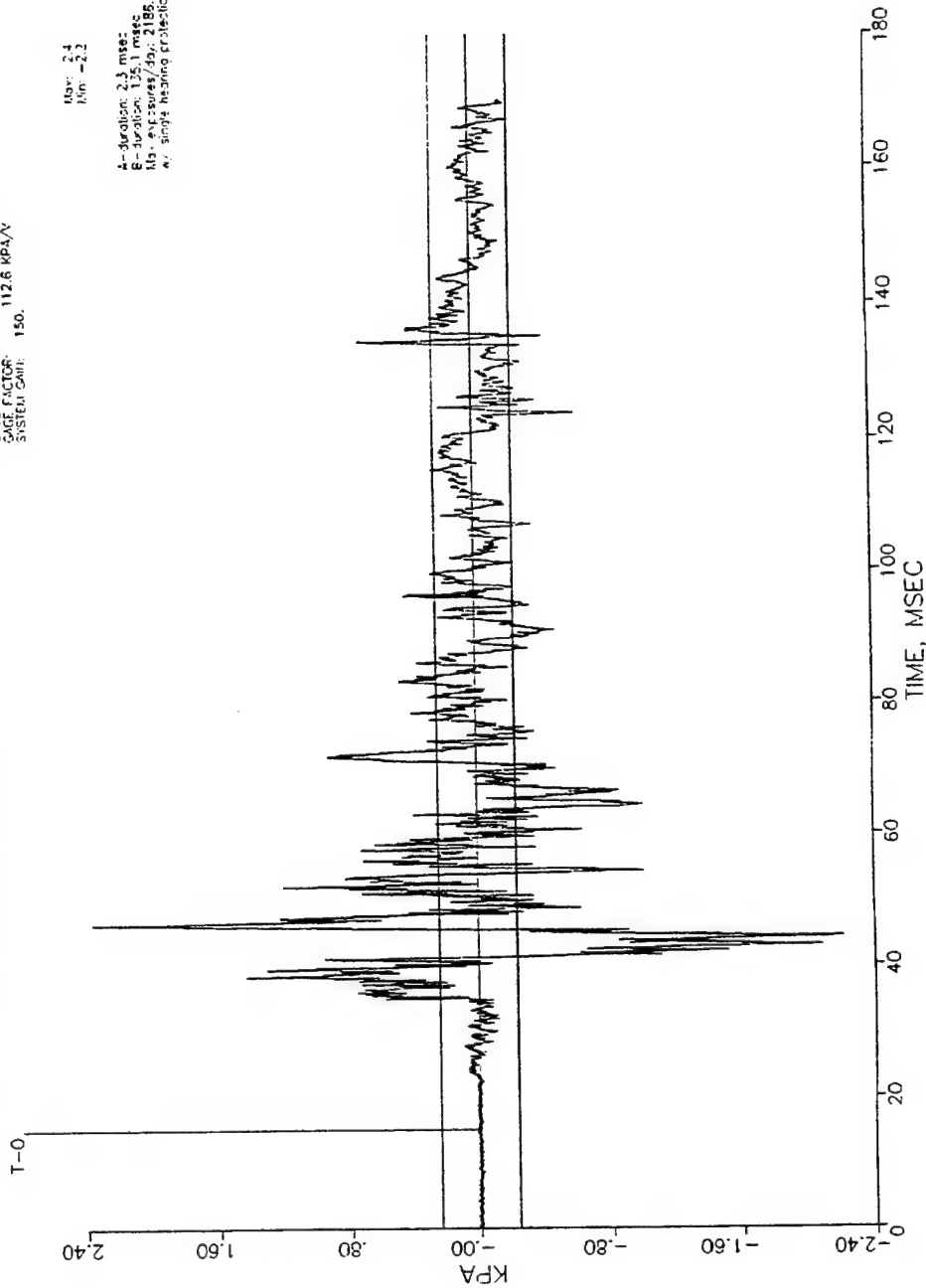


Figure B-2. Overpressure Plot for Shot 1 at the Turret Left Location

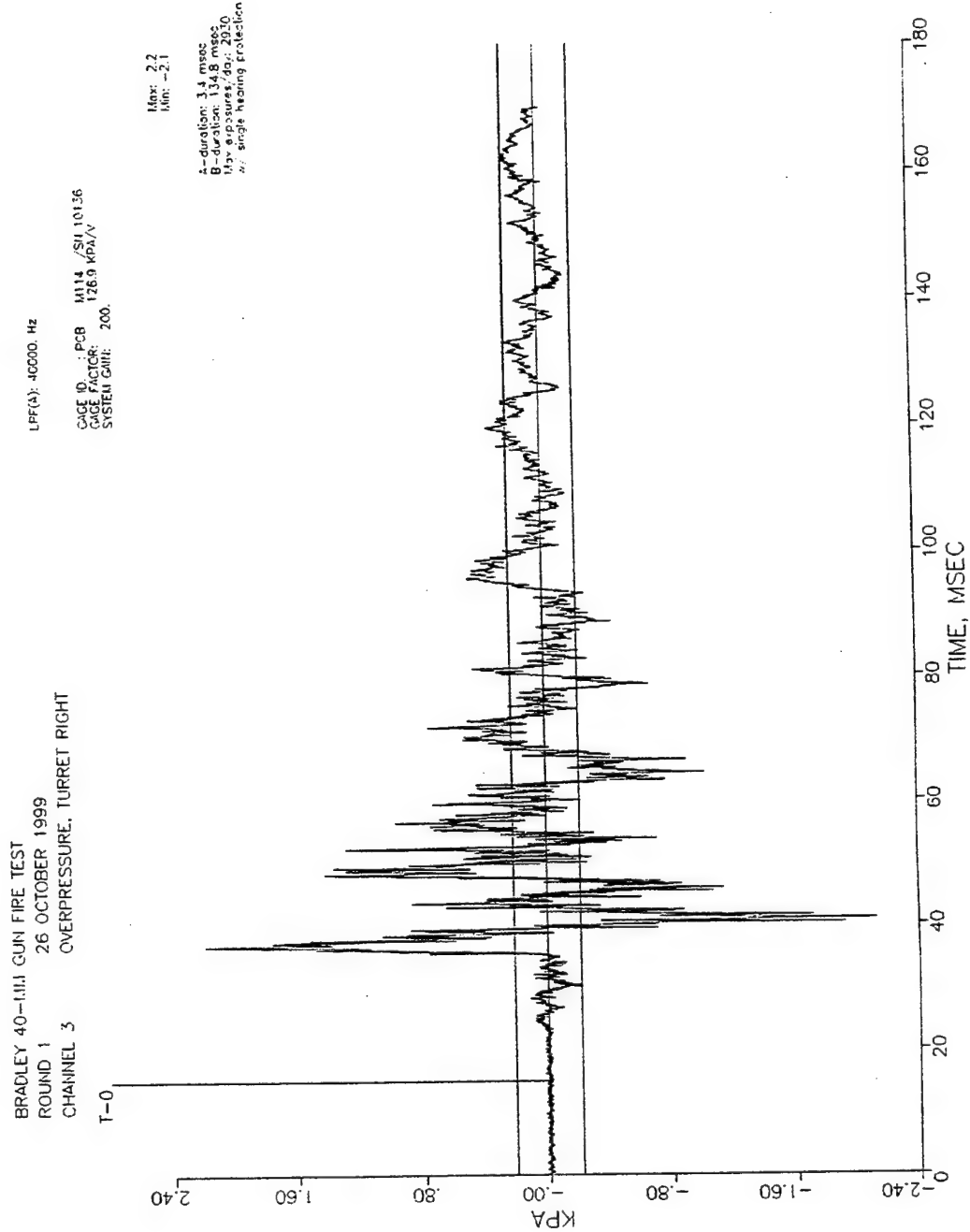


Figure B-3. Overpressure Plot for Shot 1 at the Turret Right Location

BP4CLEY 40-NIM GUIH FIRE TEST
 ROUND 1 26 OCTOBER 1999
 CHANNEL 4 OVERPRESSURE, REAR INSIDE HULL

LPF(A): 40000. Hz

GAGE ID: PCB M114 /SI10134
 GAGE FACTOR: 133.0 MPa/V
 SYSTEM GAIN: 200.

Max: 6.9
 Min: -5.7
 A-duration: 13.0 msec
 B-duration: 131.3 msec
 Rise exposure/dB: 32
 A: single heating protection

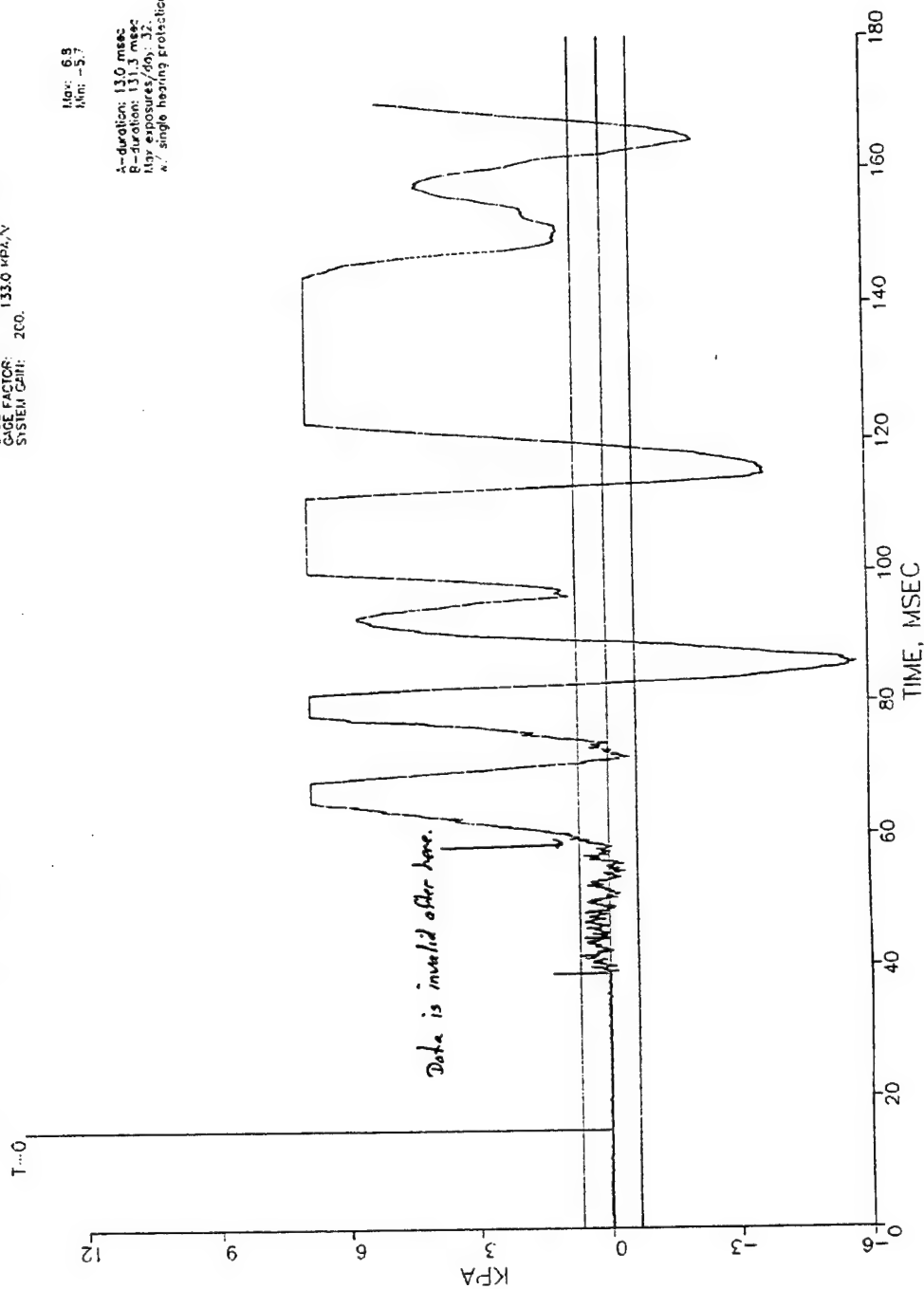


Figure B-4. Overpressure Plot for Shot 1 at the Rear Crew Area Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 2 26 OCTOBER 1999
 CHANNEL 1 OVERPRESSURE, DRIVER

LPT(1): 40000 Hz

GAGE ID: PCB M114 /SII 4331
 GAGE FACTOR: 105.1 KPA/V
 SYSTEM GAIN: 100

Max: 1.000
 Min: -573

A-duration: 7.1 msec
 B-duration: 139.6 msec
 Max exposure/day: 64832
 A: single hearing protection

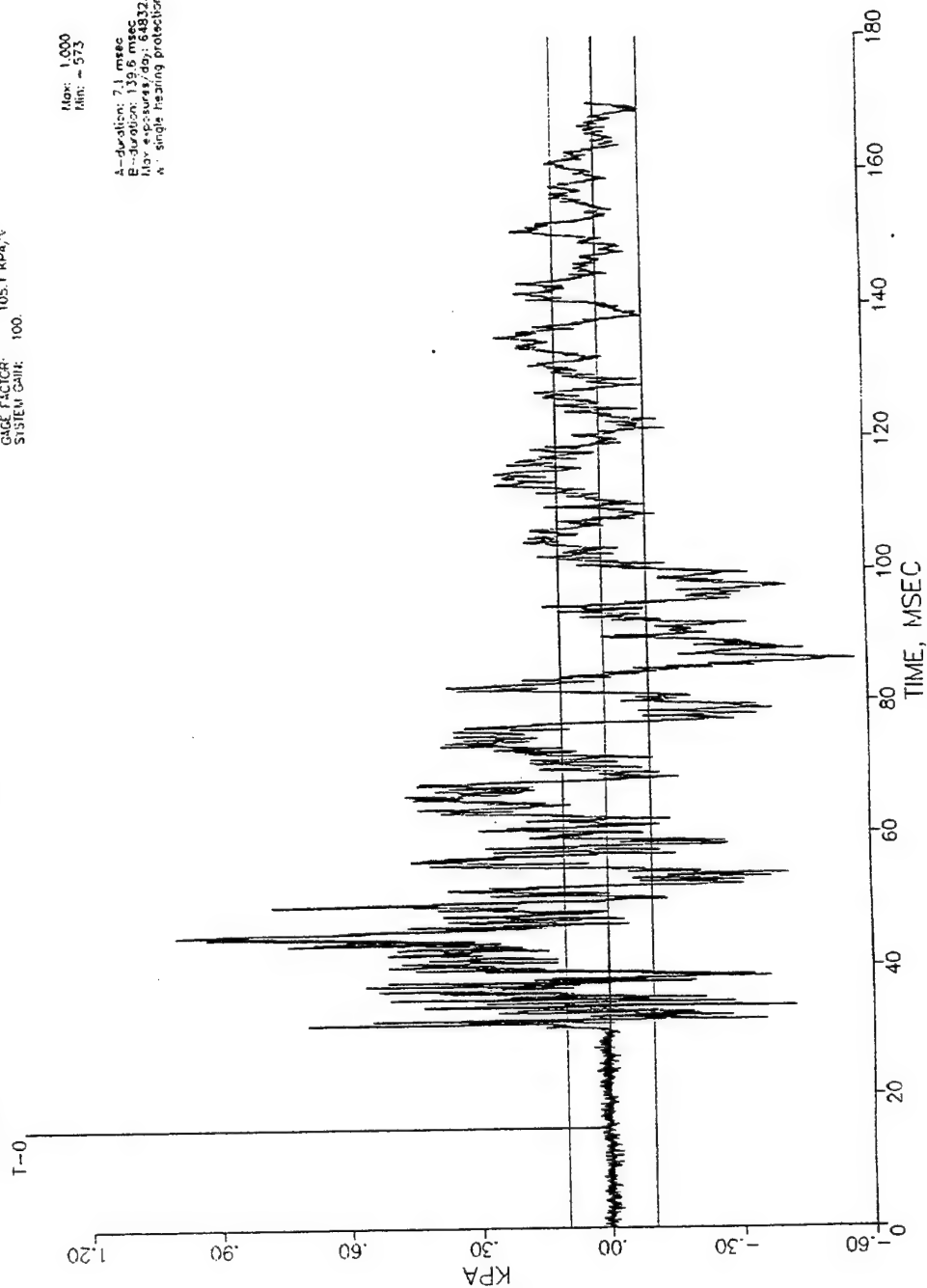


Figure B-5. Overpressure Plot for Shot 2 at the Driver Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 2
 CHANNEL 2 OVERPRESSURE, TURRET LEFT

LPR(1): 40000.0 HZ

GAGE ID: PCB M114 / 5114333
 GAGE FACTOR: 112.8 KPA/V
 SYSTEM GAIN: 100

Max: 2.9
 Min: -2.3

A-duration: 2.9 msec
 B-duration: 102.4 msec
 1/30 exposures/day, 2092
 w. single heating protection

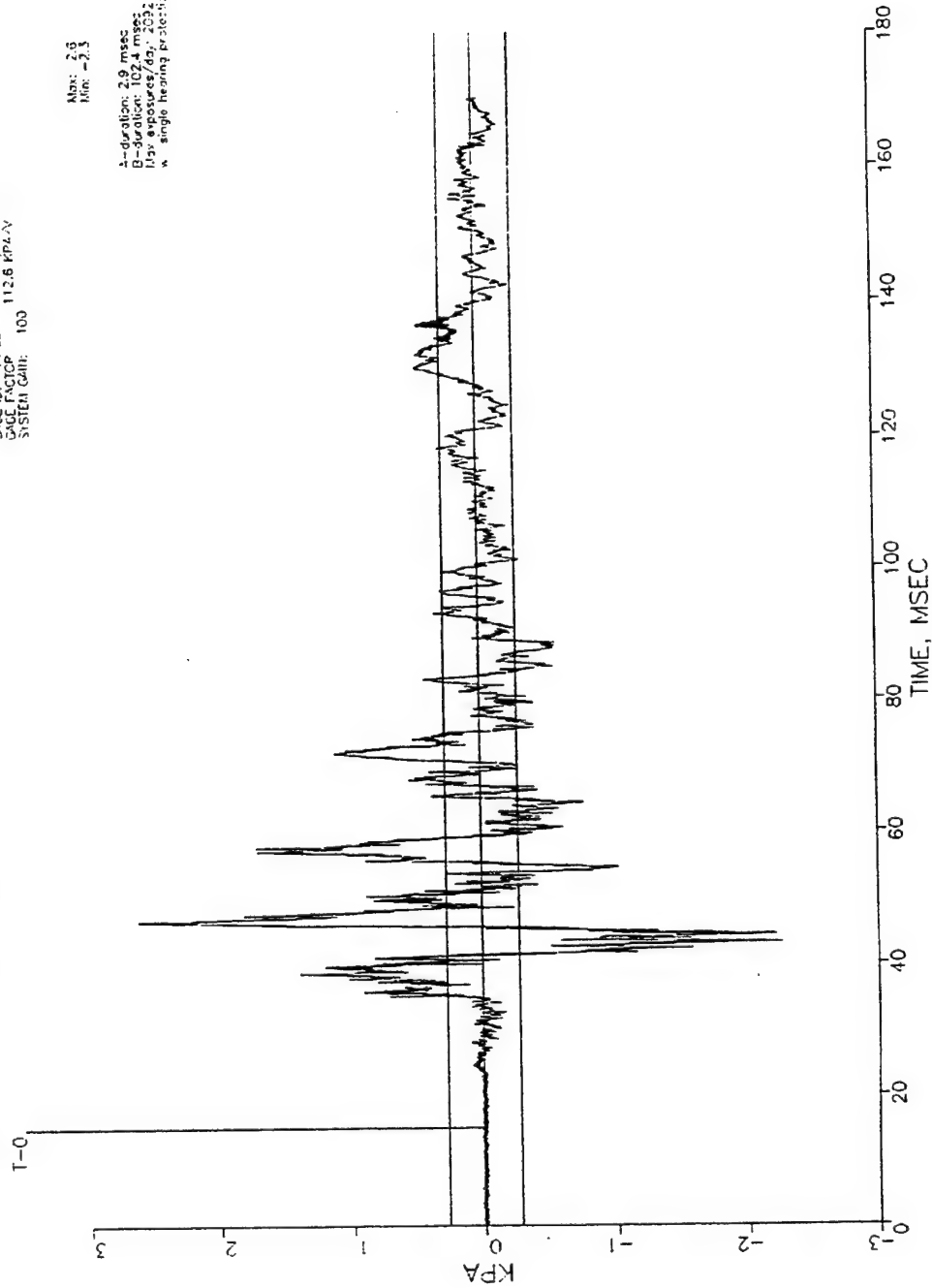


Figure B-6. Overpressure Plot for Shot 2 at the Turret Left Location

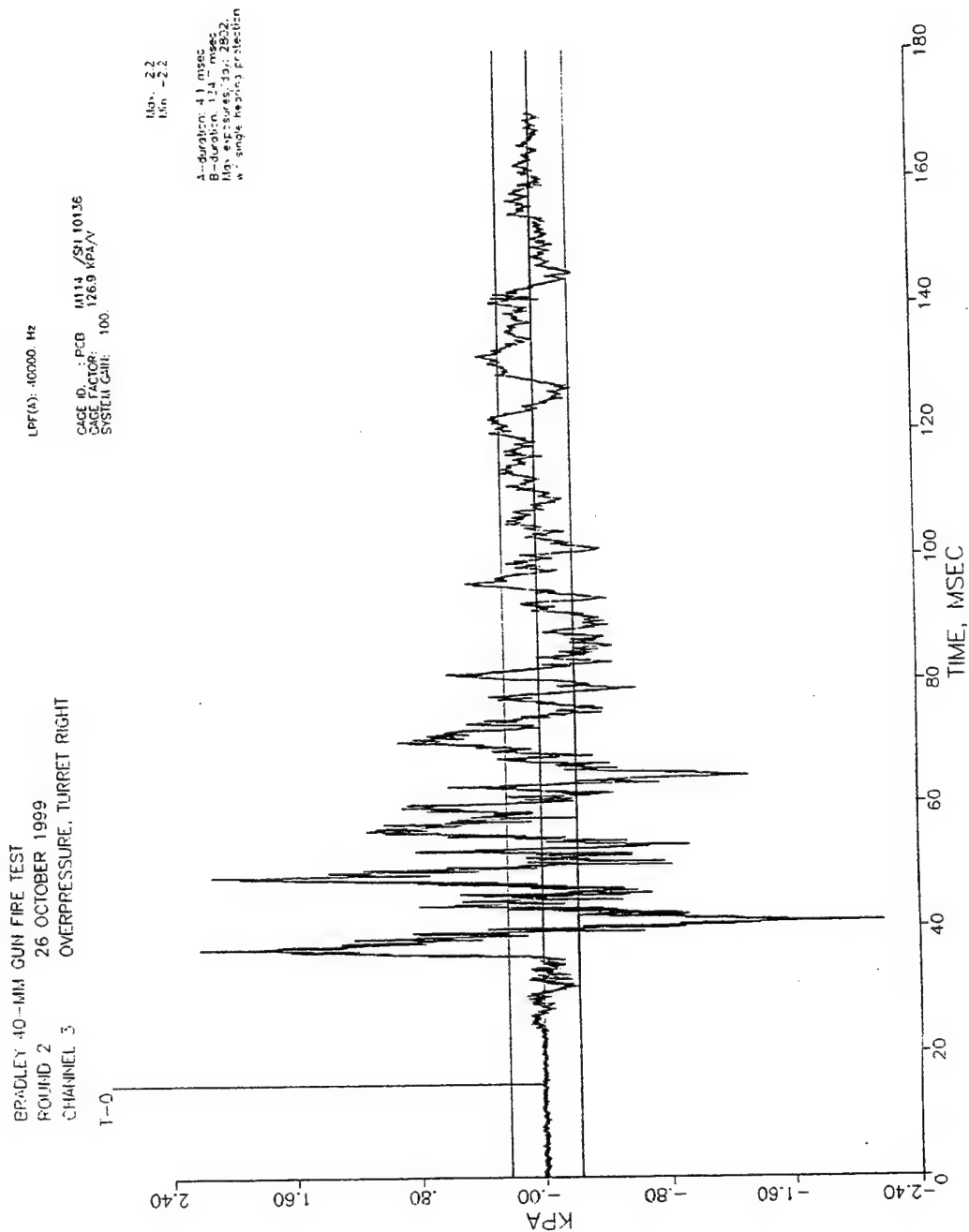


Figure B-7. Overpressure Plot for Shot 2 at the Turret Right Location

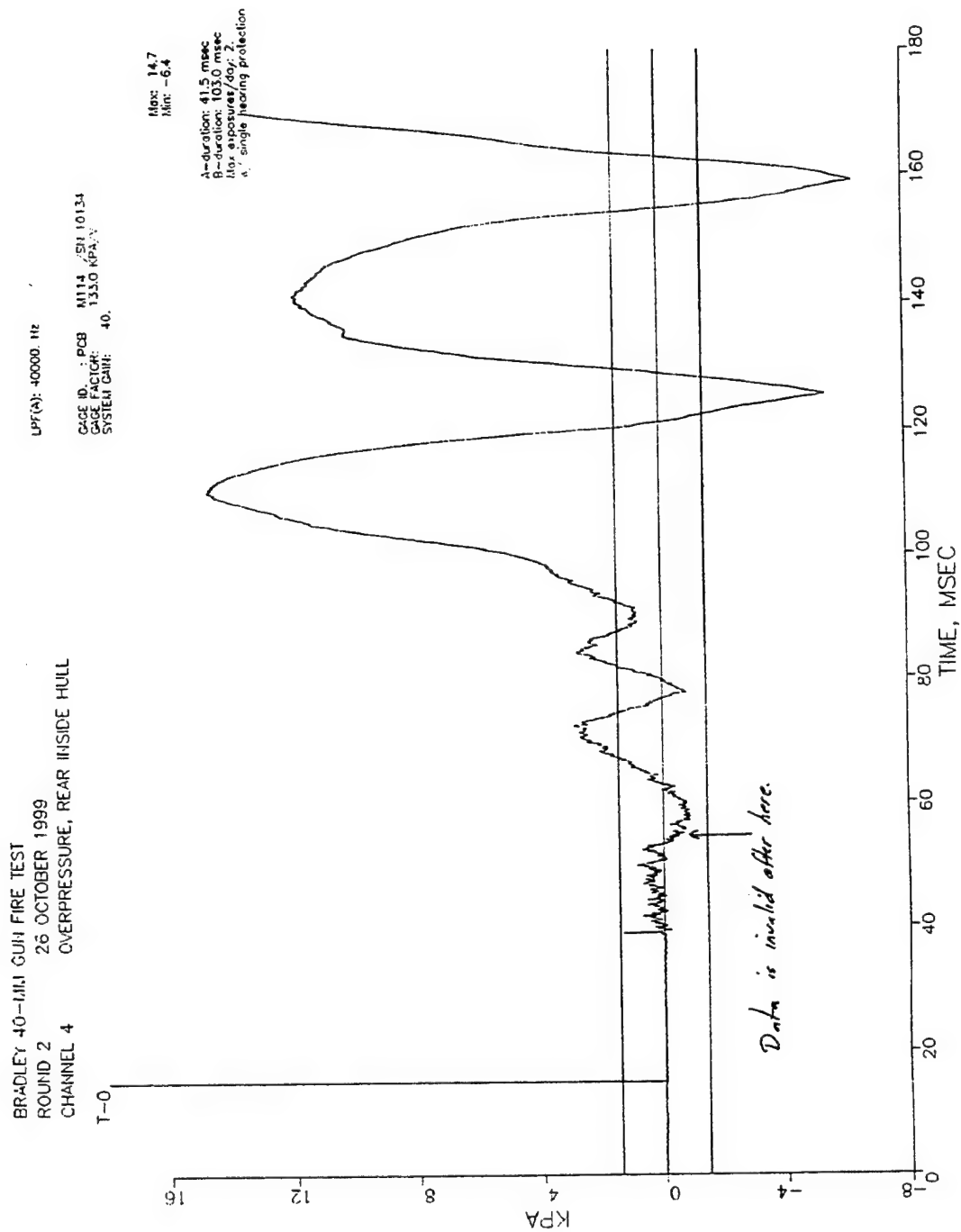


Figure B-8. Overpressure Plot for Shot 2 at the Rear Crew Area Location

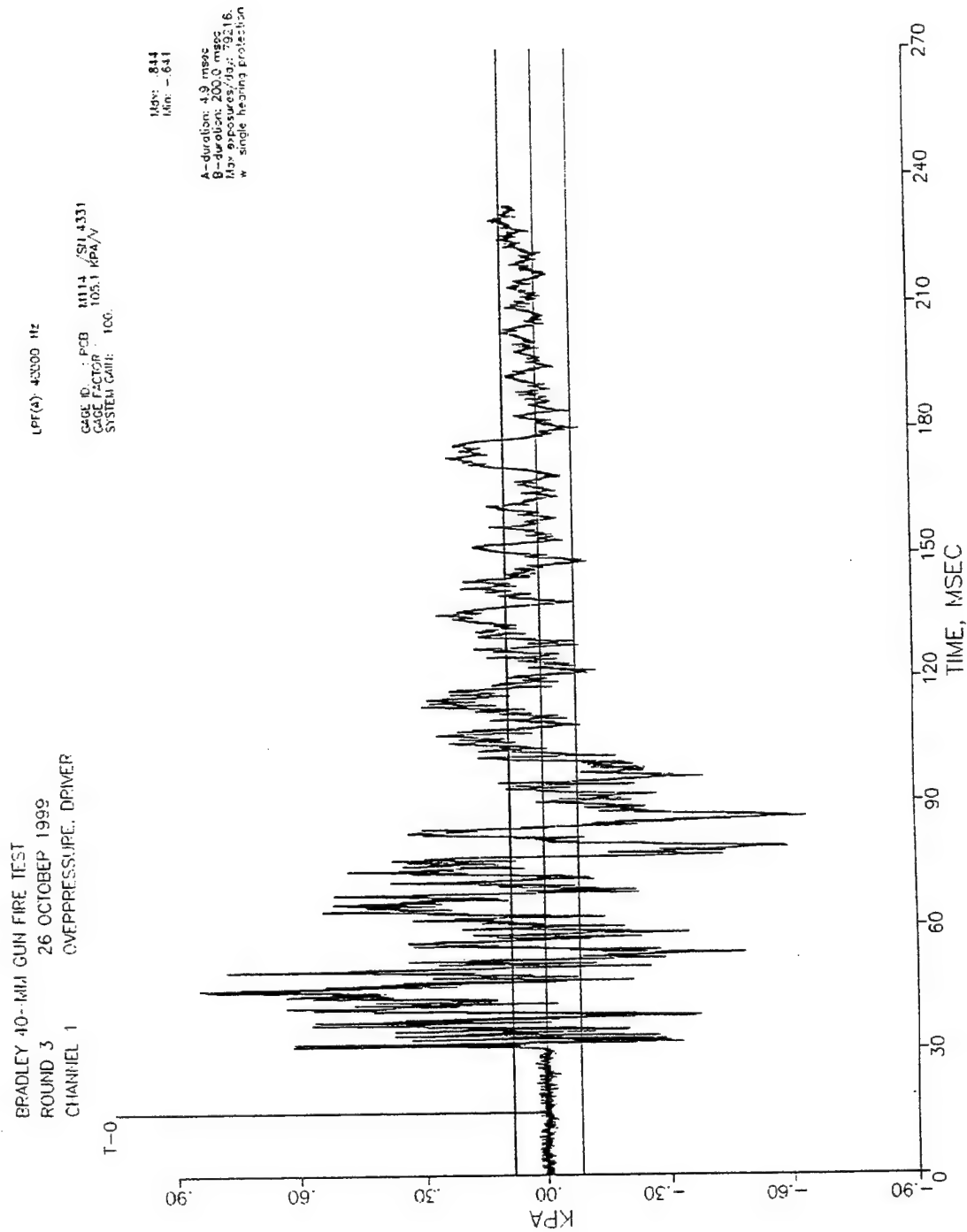


Figure B-9. Overpressure Plot for Shot 3 at the Driver Location

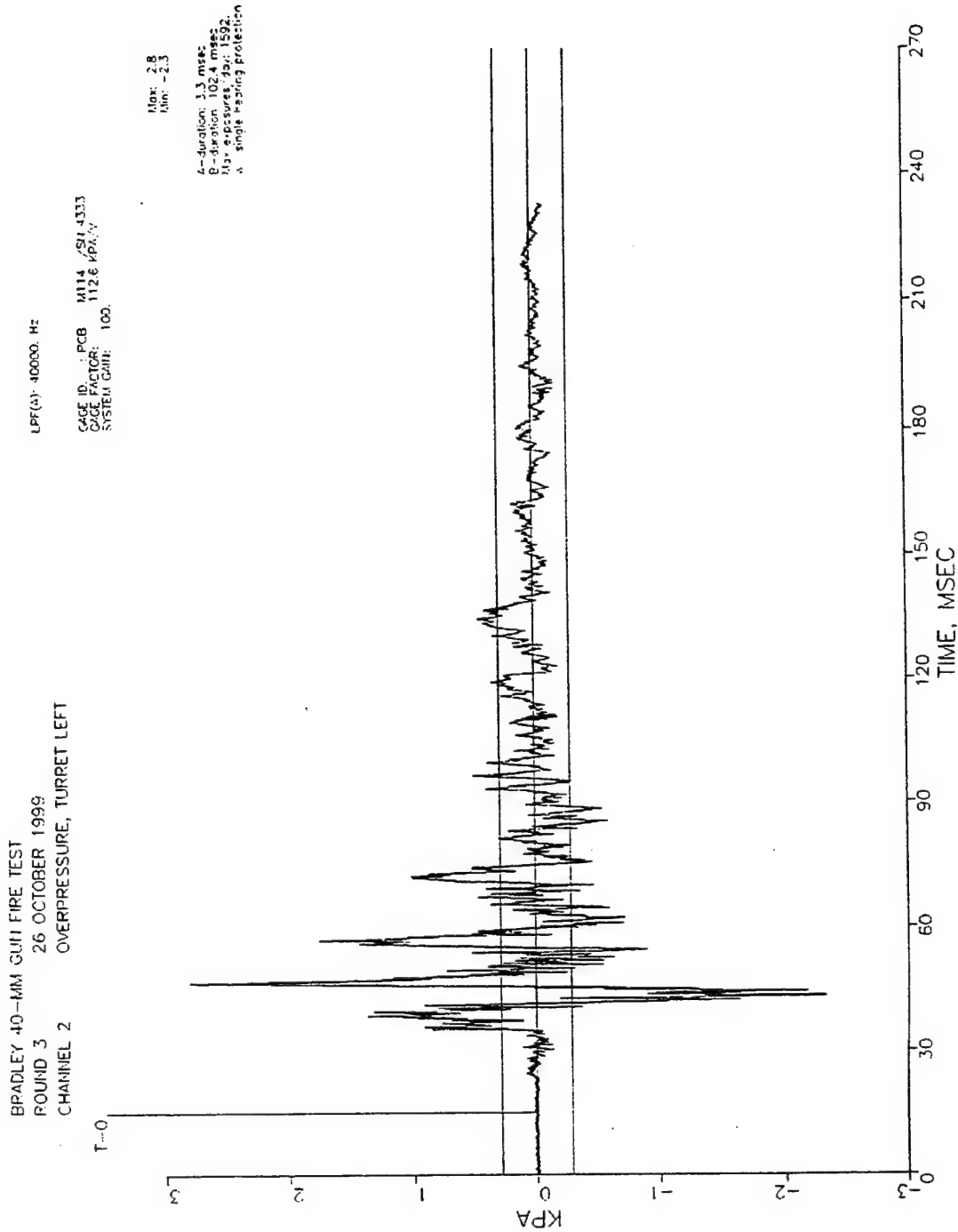


Figure B-10. Overpressure Plot for Shot 3 at the Turret Left Location

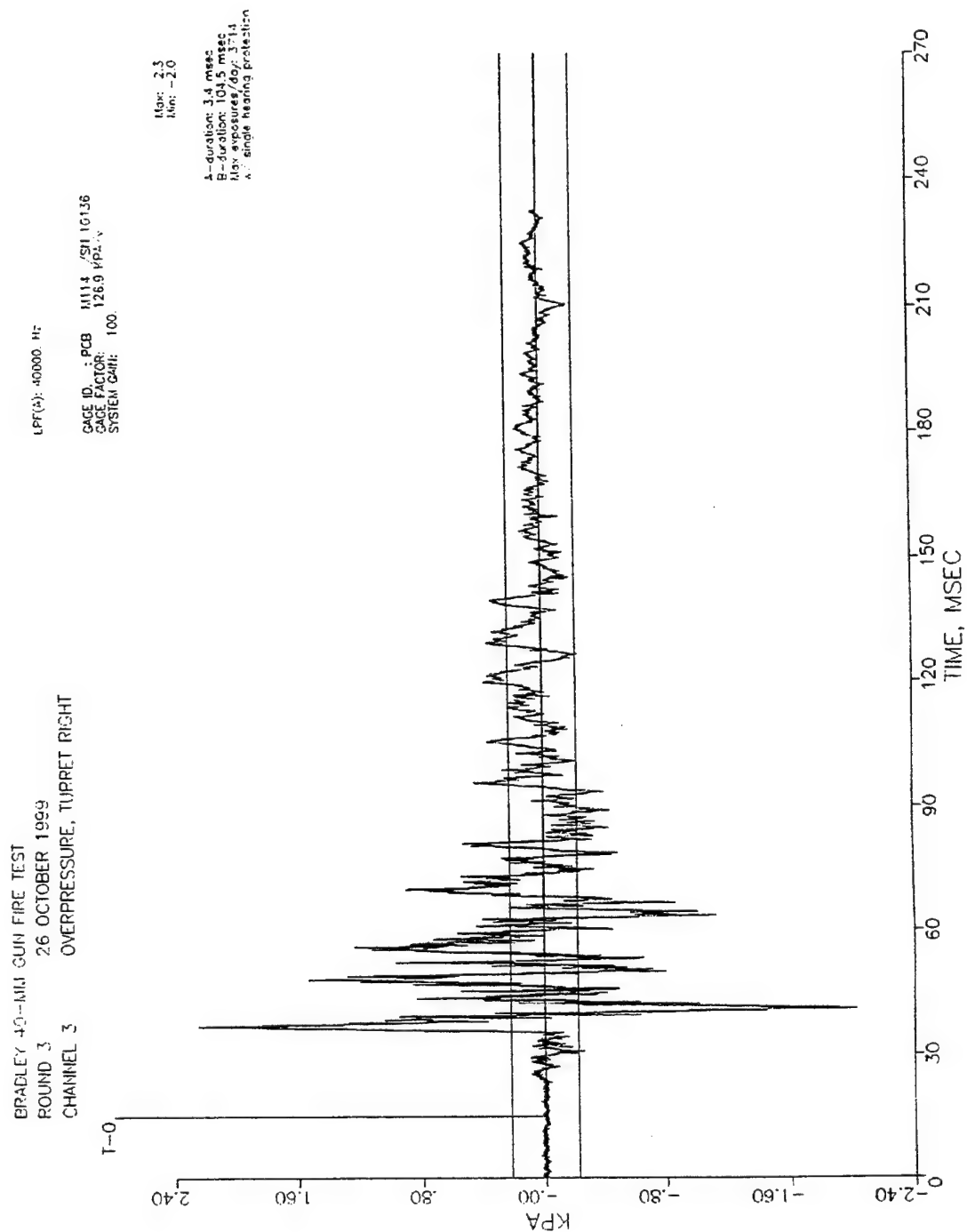


Figure B-11. Overpressure Plot for Shot 3 at the Turret Right Location

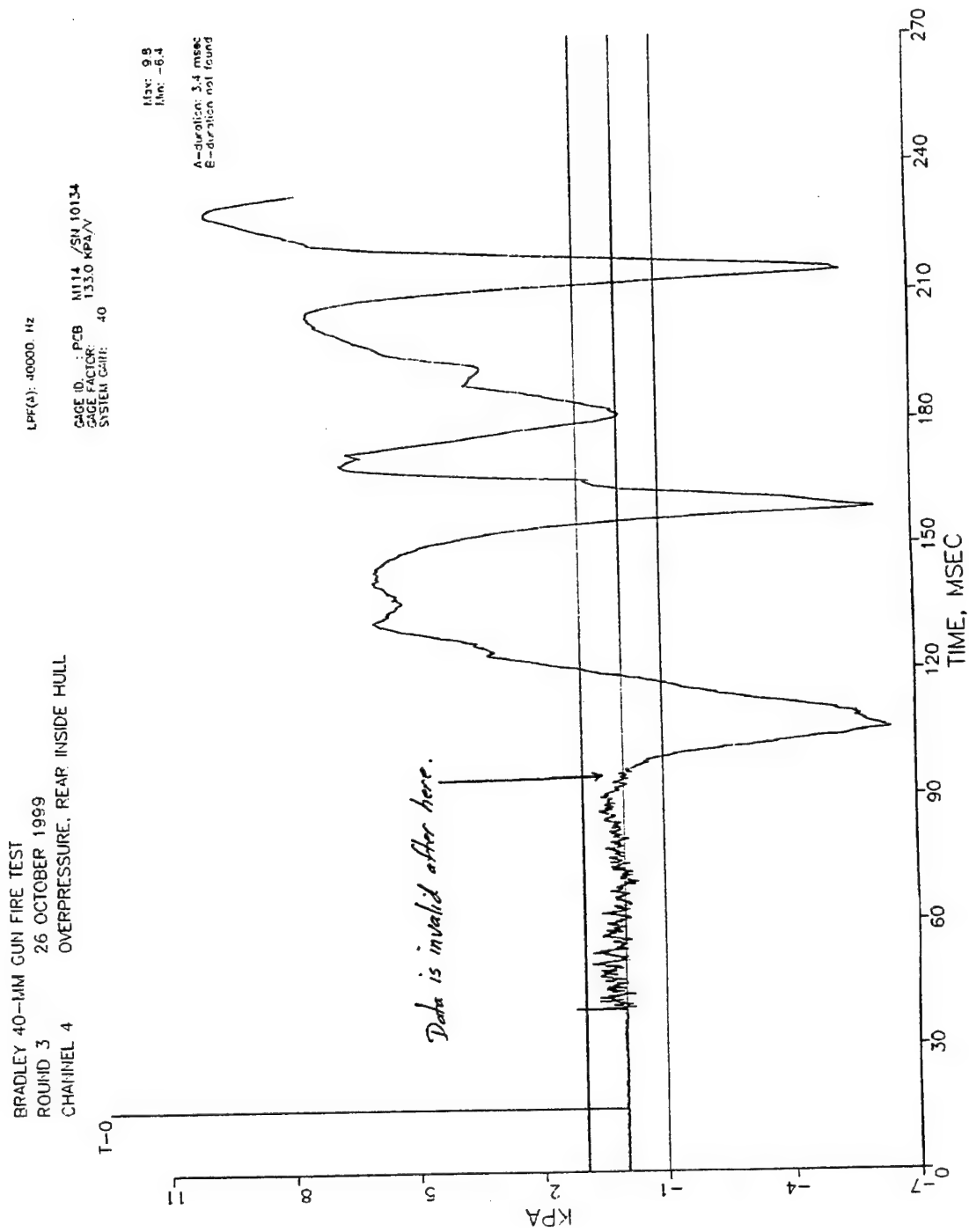


Figure B-12. Overpressure Plot for Shot 3 at the Rear Crew Area Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 4 27 OCTOBER 1999
 CHANNEL 1 OVERPRESSURE, DRIVER

LPF(A): 10000. Hz

GAGE ID.: PCB M114 /SII 4331
 GAGE FACTOR: 105.1 KPA/V
 SYSTEM GAIN: 100.

Max: .959
 Min: -.634

2-duration: 8 msec
 3-duration: 34.73 msec
 10-sensitivity: 74.701
 4-single hearing protection

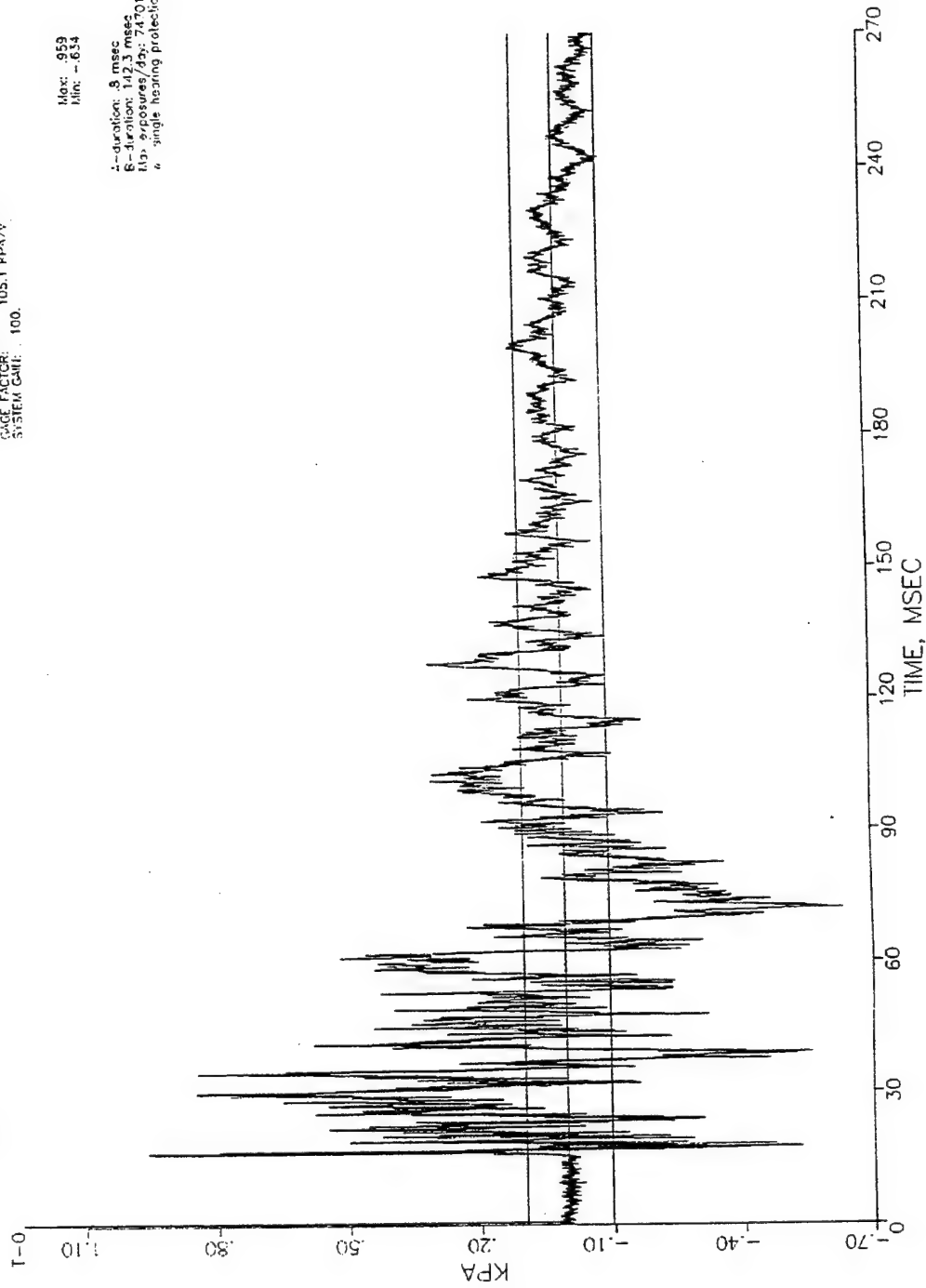


Figure B-13. Overpressure Plot for Shot 4 at the Driver Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 4 27 OCTOBER 1999
 CHANNEL 2 OVERPRESSURE, TURRET LEFT

LFF(A): 40000. Hz

CAGE ID: PCB M114 /SN 4333
 GAGE FACTOR: 112.6 KPA/V
 SYSTEM GAIN: 150.

Max: 3.0
 Min: -2.4

A-duration: 4.4 msec
 B-duration: 123.1 msec
 Max exposure: 137.1195
 v. single hearing protection

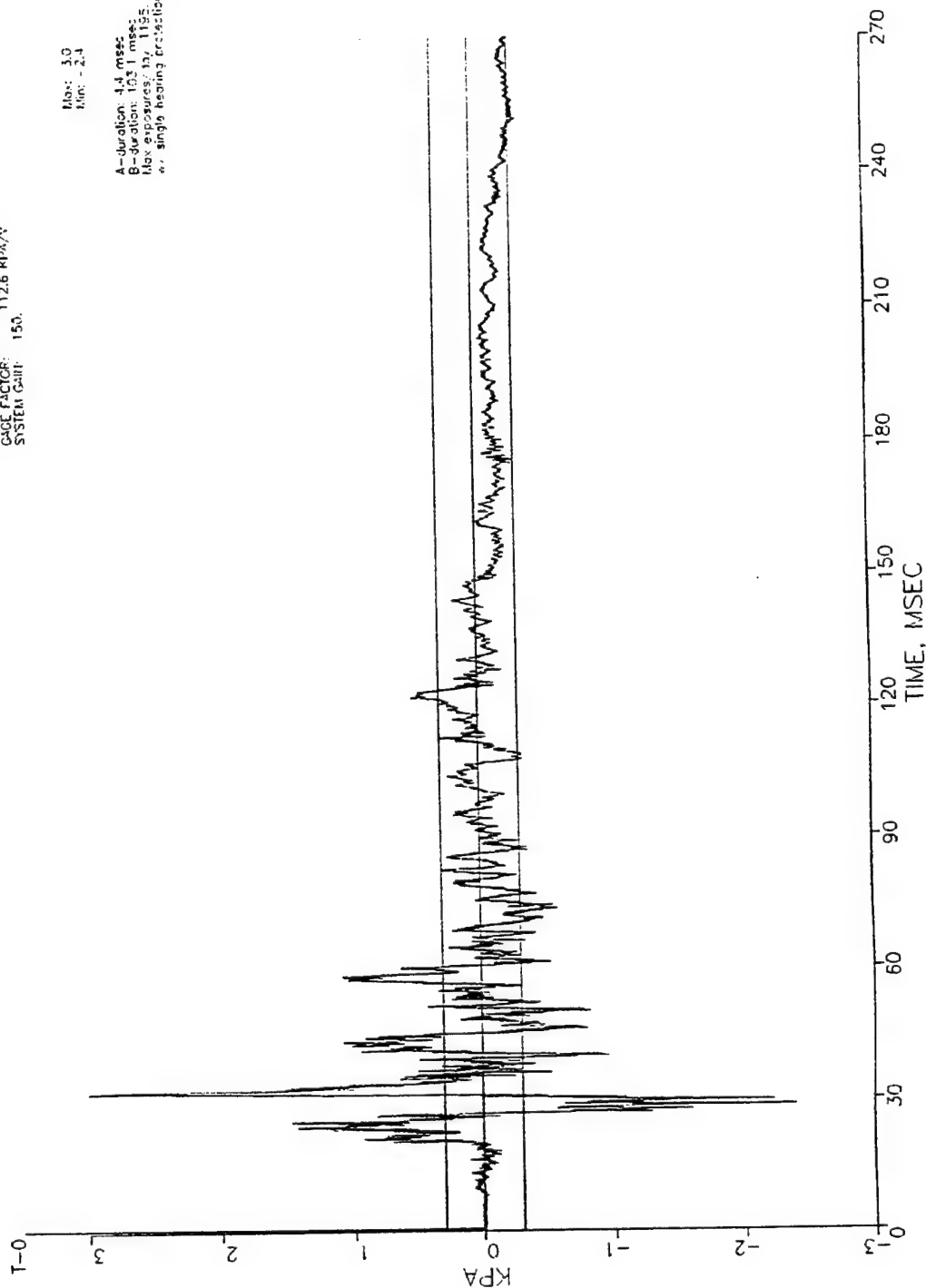


Figure B-14. Overpressure Plot for Shot 4 at the Turret Left Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 4 27 OCTOBER 1999
 CHANNEL 3 OVERPRESSURE, TURRET RIGHT

LPF(A): 40000. Hz

GAGE ID: PCB M114 /SN 10136
 GAGE FACTOR: 126.9 KPA/V
 SYSTEM GAIN: 150.

Max: 2.3
 Min: -2.1

1--duration: 4.2 msec
 5--duration: 105.4 msec
 Max exposure/day: 1398
 6--single hearing protection

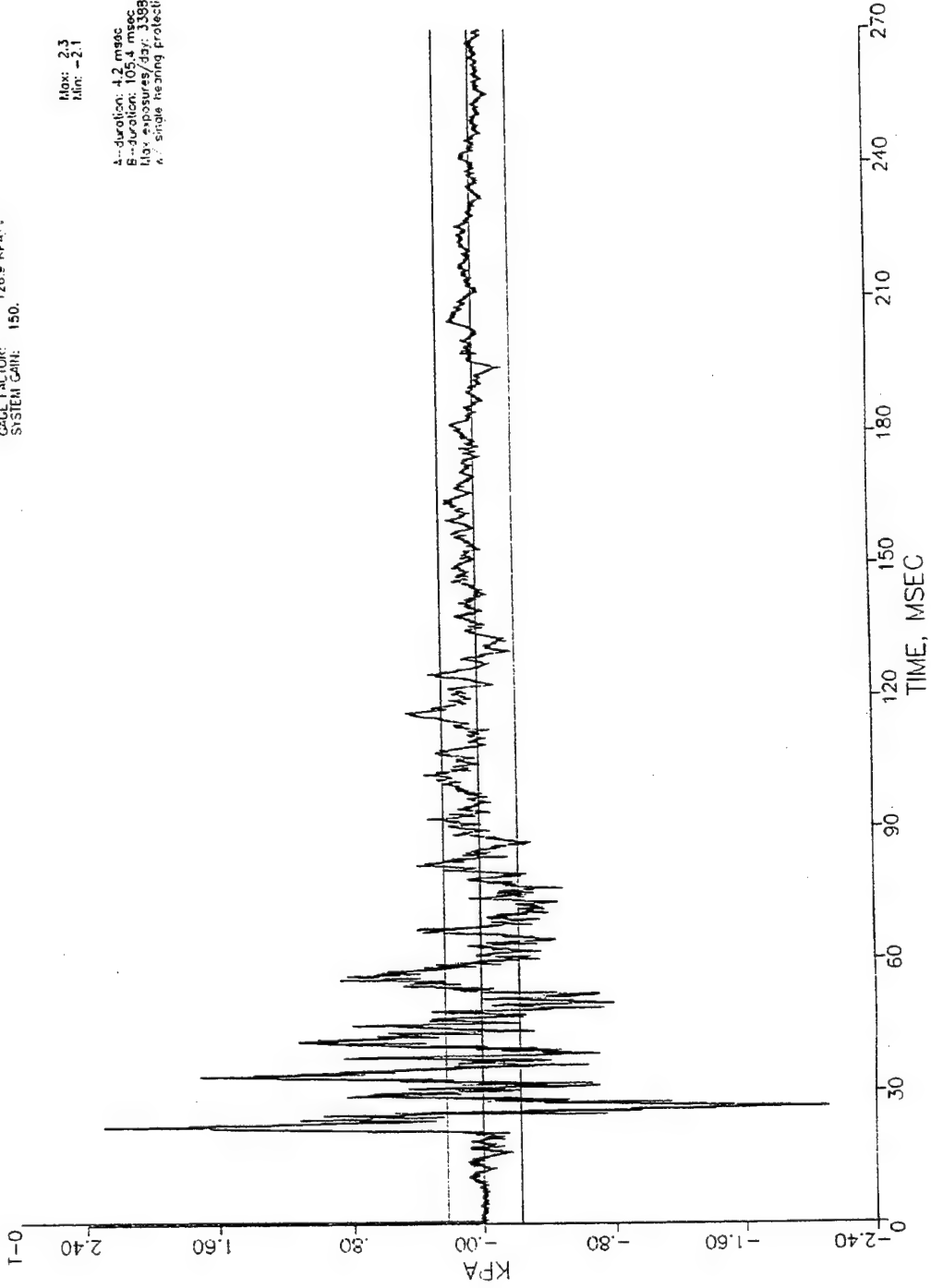


Figure B-15. Overpressure Plot for Shot 4 at the Turret Right Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 4 27 OCTOBER 1999
 CHANNEL 4 OVERPRESSURE, REAR INSIDE HULL

LPF(A): 40000. Hz

CAGE ID: PCB M114 /S1 10134
 CAGE FACTOR: 1330 KPa/V
 SYSTEM GAIN: 40.

Max: 4.1
 Min: -9.6
 A-duration: 17.3 msec
 B-duration: 200.0 msec
 IIS exposure/day: 14.5
 w/ single heading protection

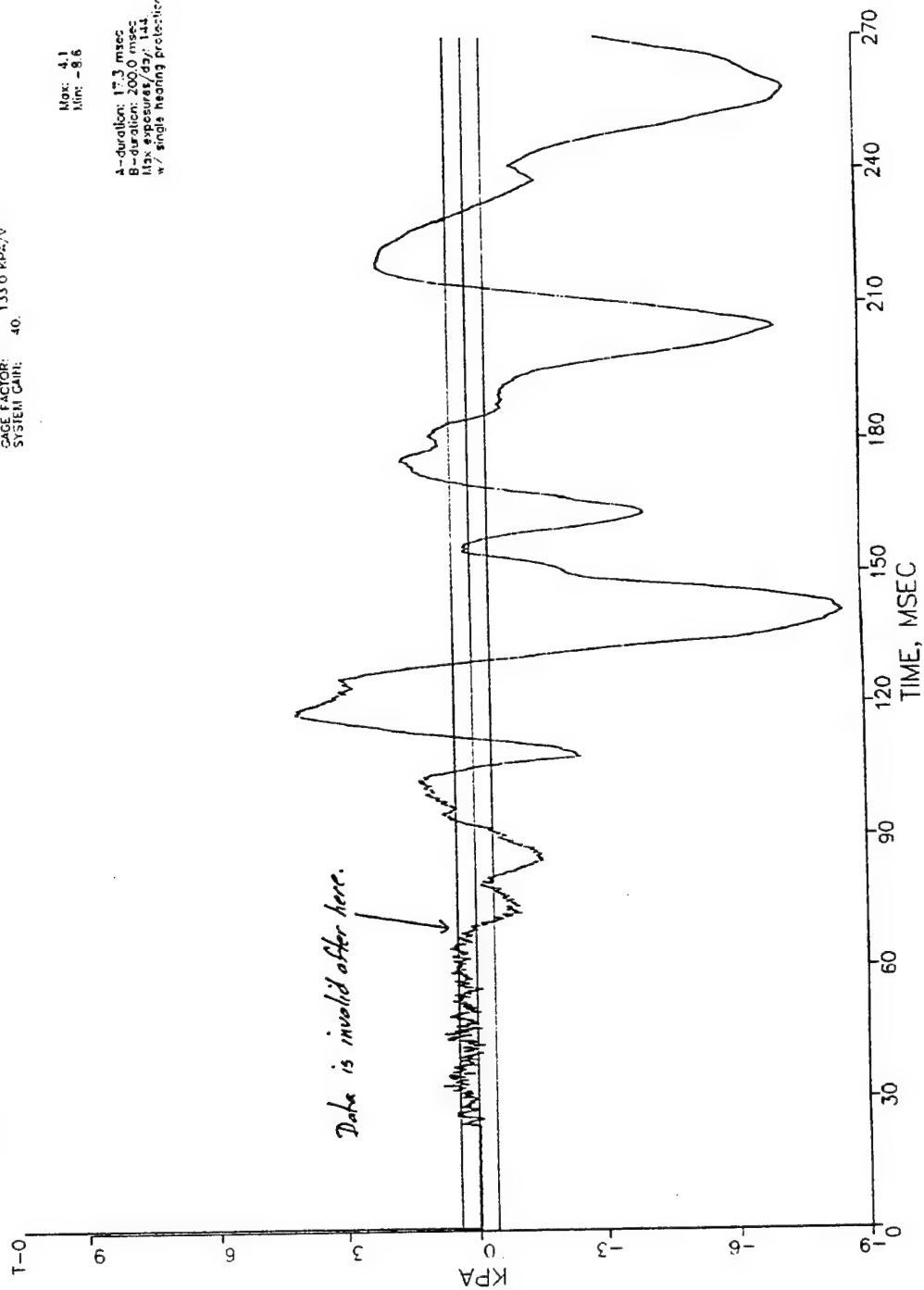


Figure B-16. Overpressure Plot for Shot 4 at the Rear Crew Area Location

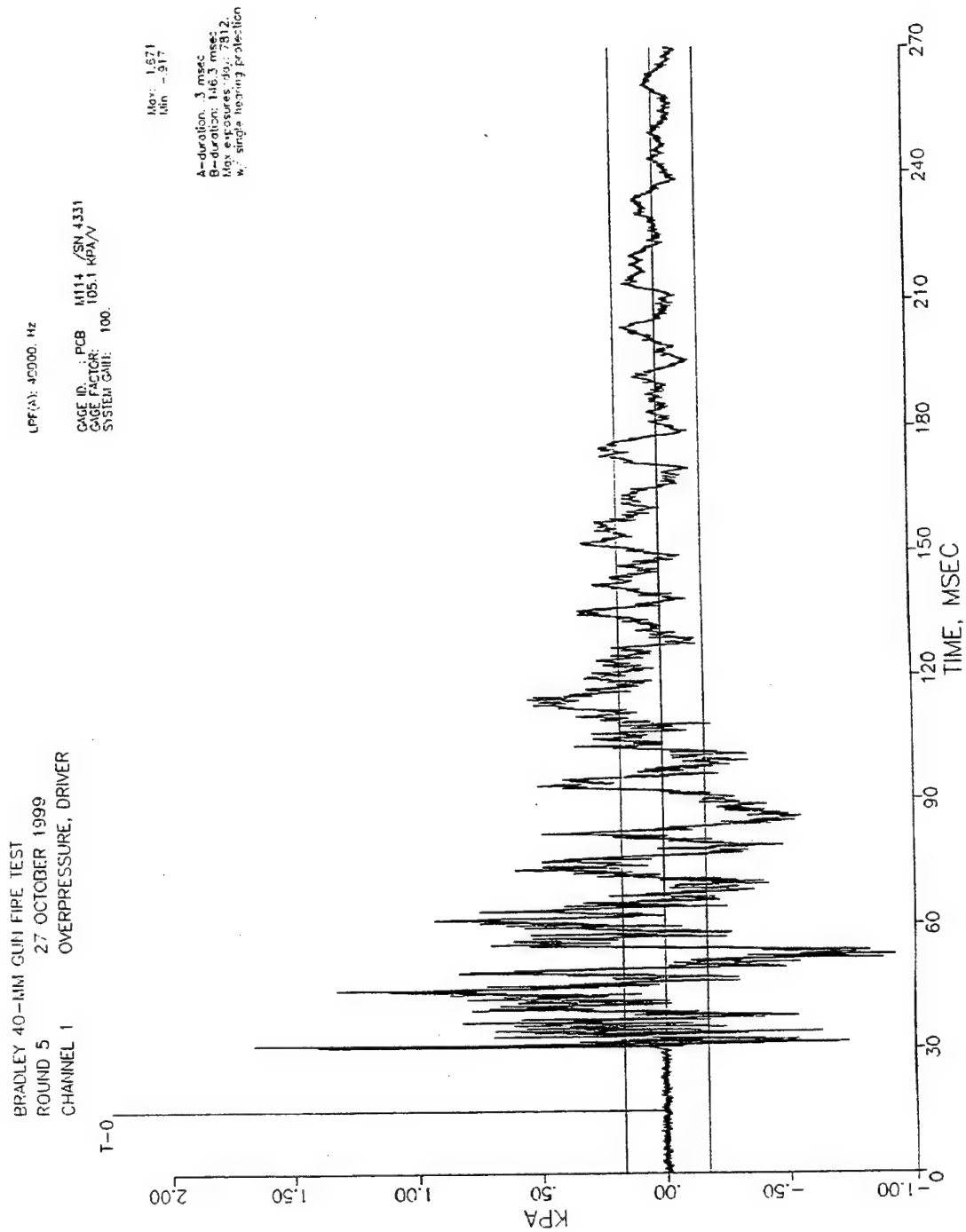


Figure B-17. Overpressure Plot for Shot 5 at the Driver Location

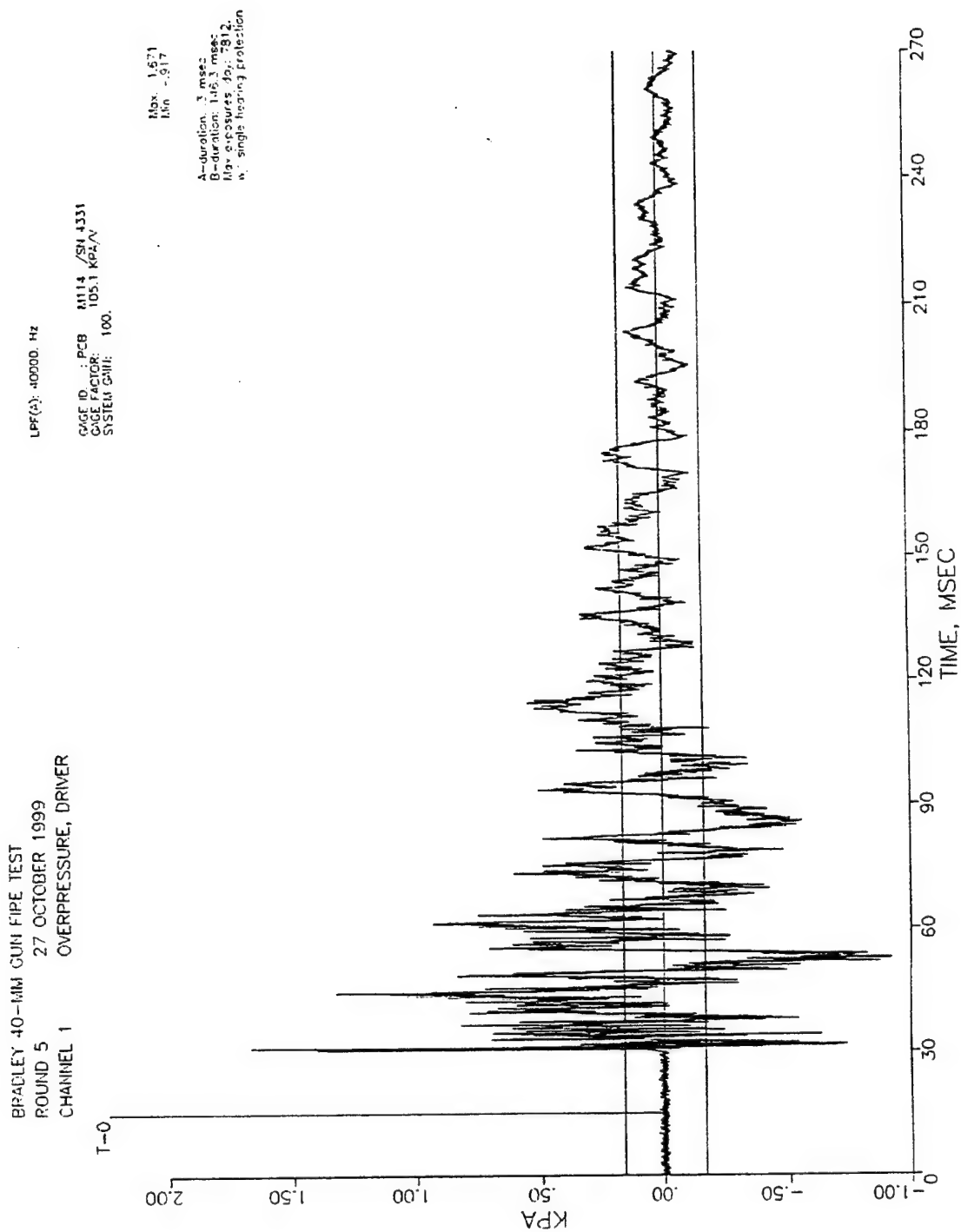


Figure B-18. Overpressure Plot for Shot 5 at the Turret Left Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 5 27 OCTOBER 1999
 CHANNEL 3 OVERPRESSURE, TURRET RIGHT

LFF(A): 40050 Hz

GAGE ID: PCB 14114 / S110136
 GAGE FACTOR: 126.9 KPA/V
 SYSTEM GAIN: 150

Max: 3.3
 Min: -3.2

A-duration: 3.8 msec
 B-duration: 107.8 msec
 Max exposures/day: 785
 w/ single hearing protection

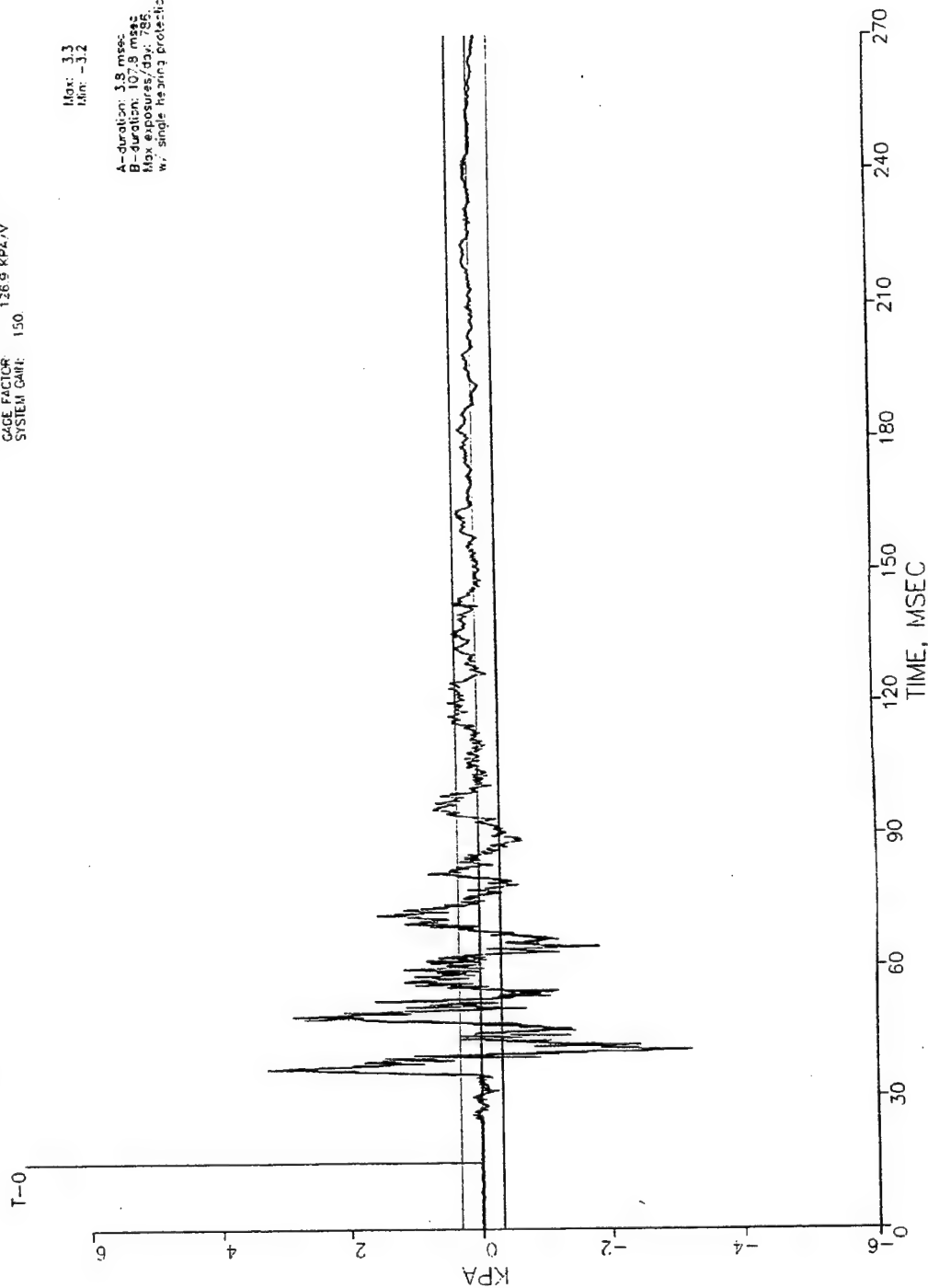


Figure B-19. Overpressure Plot for Shot 5 at the Turret Right Location

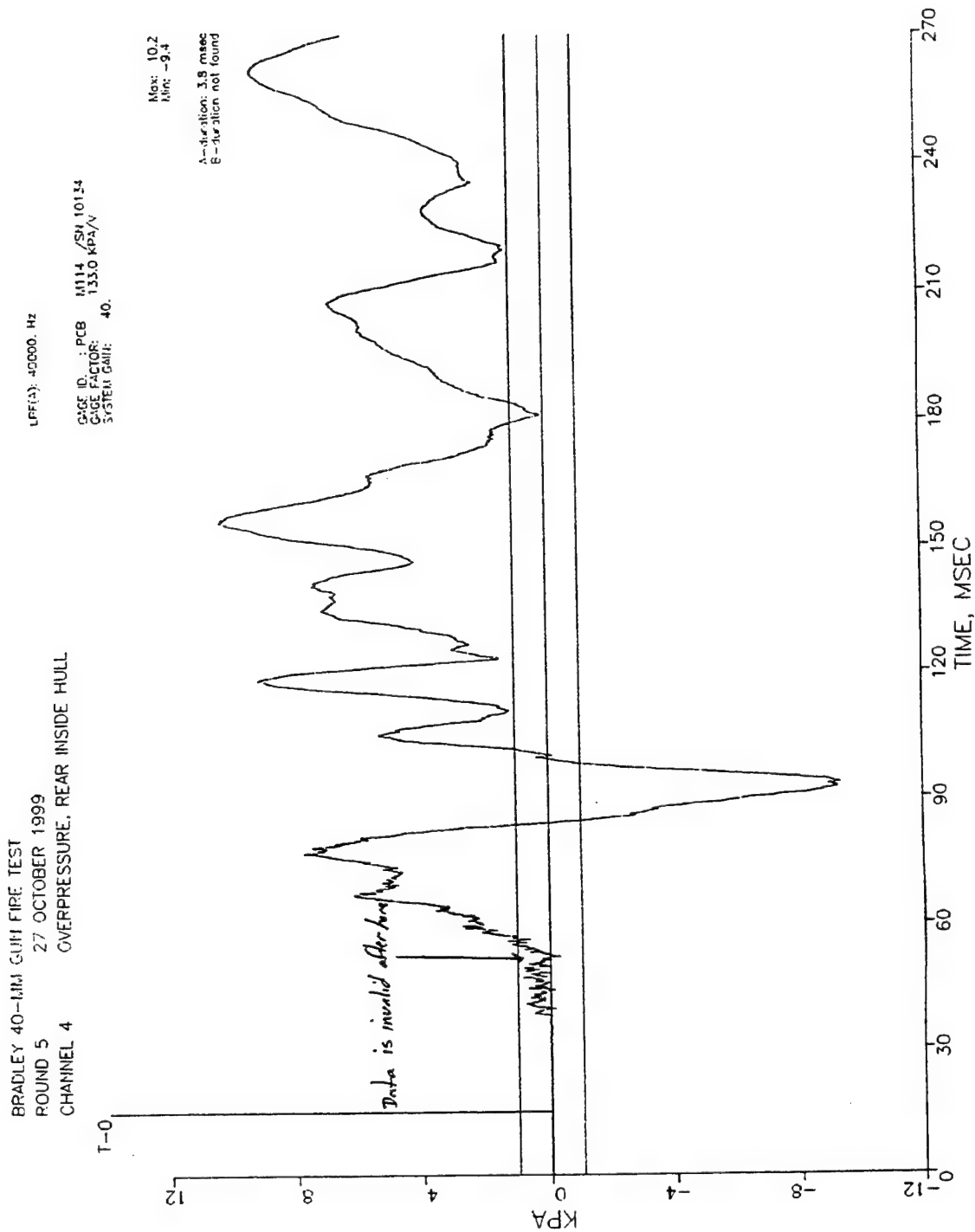


Figure B-20. Overpressure Plot for Shot 5 at the Rear Crew Area Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 6 27 OCTOBER 1999
 CHANNEL 1 OVERPRESSURE, DRIVER

UPF(A): 40000. Hz

CAGE ID: PCB M114 /SUJ331
 CAGE FACTOR: 105.1 KPa/V
 SYSTEM GAIN: 100.

Max: 1.7
 Min: -1.1

A-duration: .5 msec
 B-duration: 145.2 msec
 Max exposure: 32.7 V
 4 - single reading pre-tilt

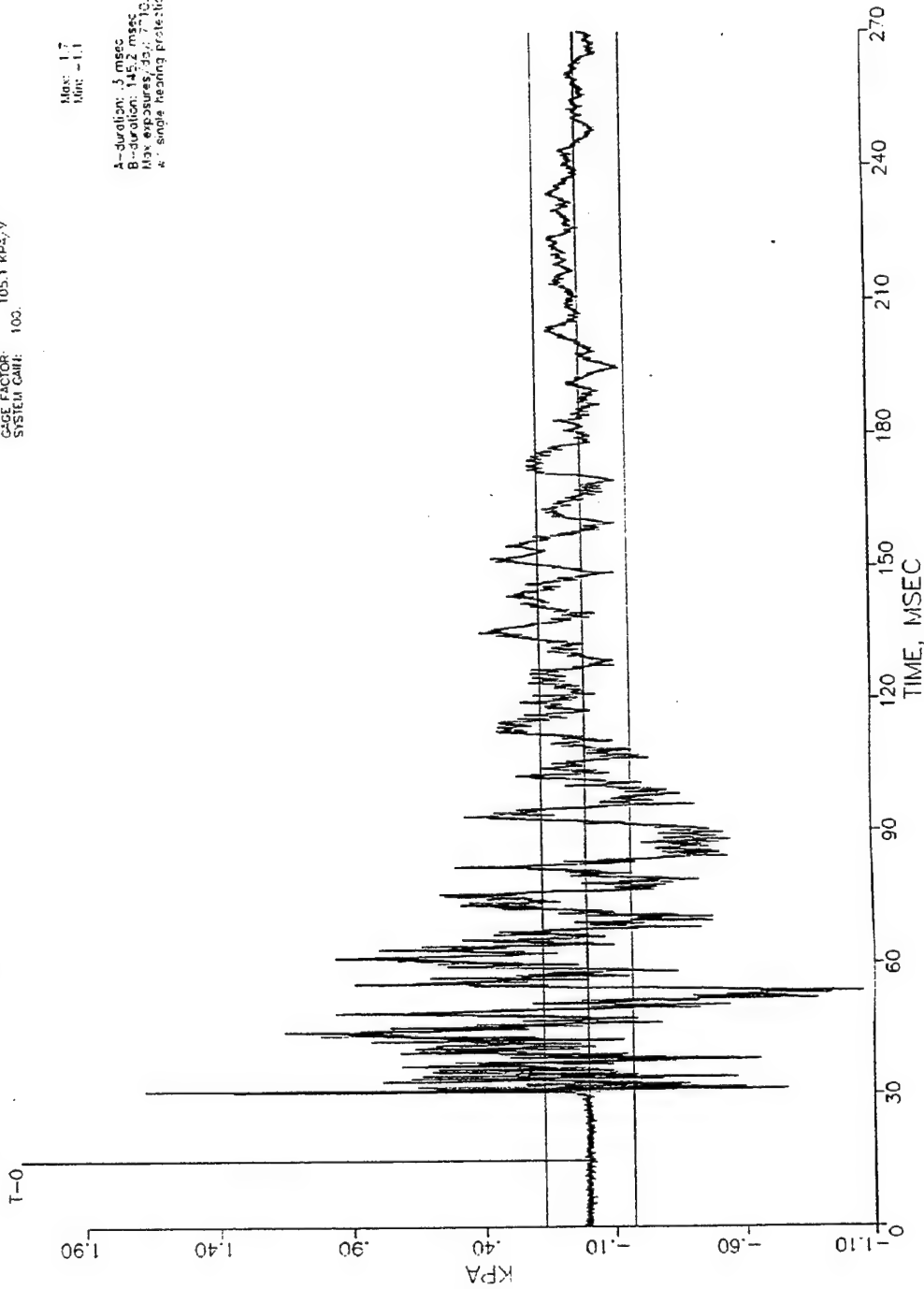


Figure B-21. Overpressure Plot for Shot 6 at the Driver Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 6 27 OCTOBER 1999
 CHANNEL 2 OVERPRESSURE, TURRET LEFT

LPF(A): 40000 Hz

CAGE ID : PCB M114 /SN 4333
 GAGE FACTOR 112.6 KPA/V
 SYSTEM CALIB 100

Max: 3.3
 Min: -4.1

A-duration: 1.4 msec
 B-duration: 105.0 msec
 Max exposure: 92.837
 n single hearing Protection

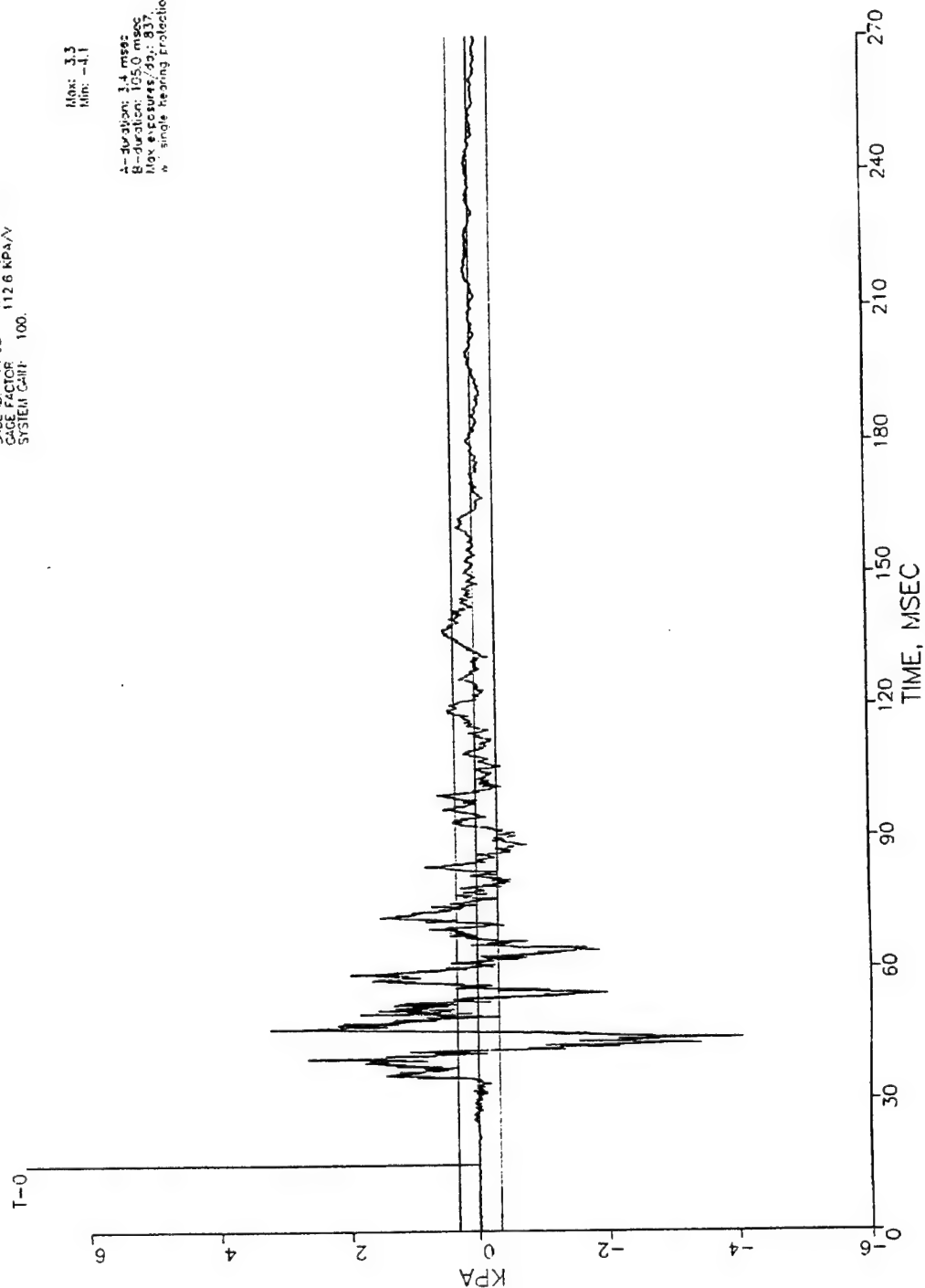


Figure B-22. Overpressure Plot for Shot 6 at the Turret Left Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 6 27 OCTOBER 1999
 CHANNEL 3 OVERPRESSURE, TURRET RIGHT

LPF(H): 40000. HZ

GAGE ID.: PCB M114 /S/110136
 GAGE FACTOR: 1269 KPA/V
 SYSTEM GAIN: 150.

Max: 3.4
 Min: -3.3

A-duration: 40 msec
 B-duration: 107 msec
 In: 676
 Out: 676
 A: single hearing protection

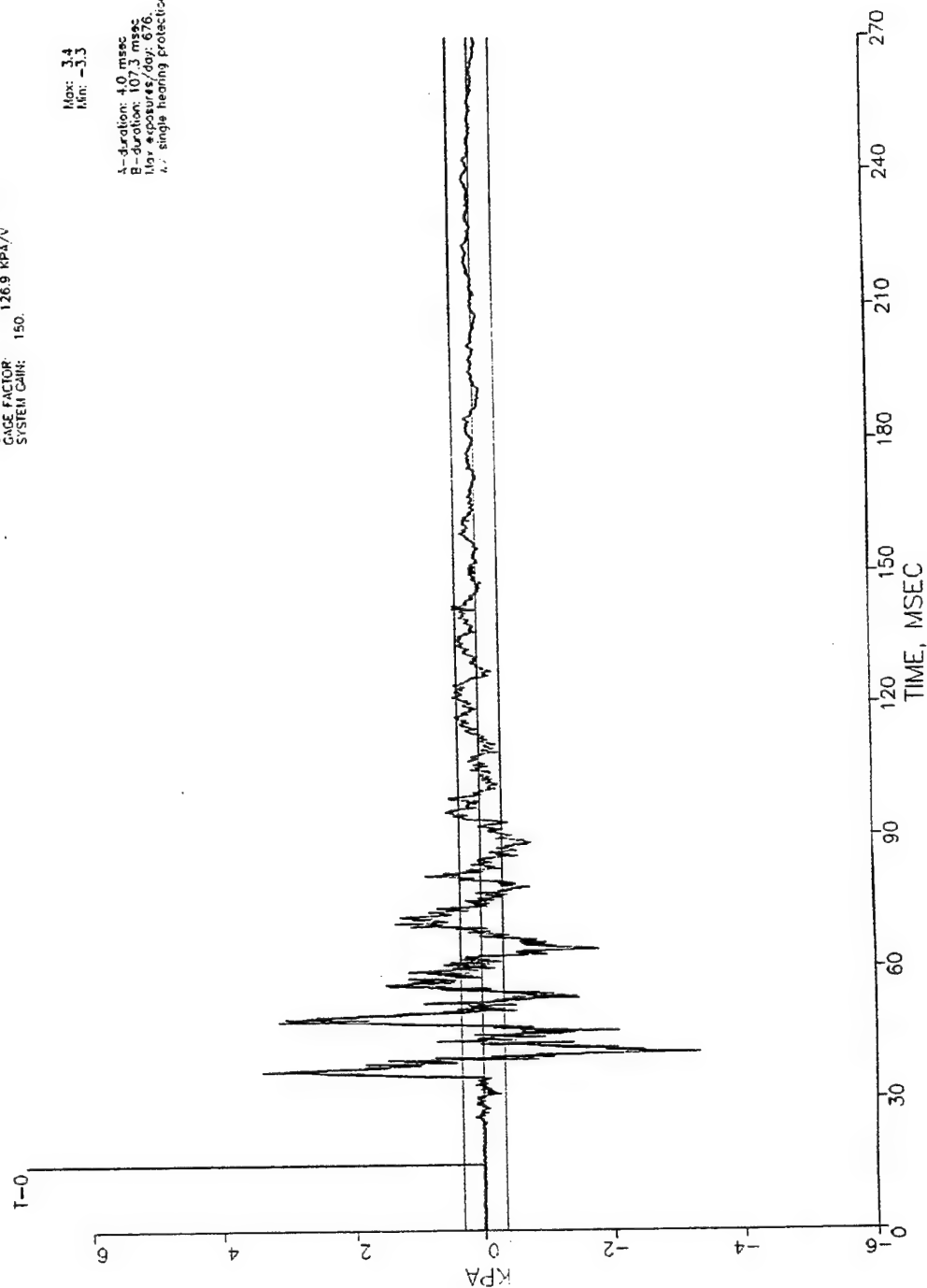


Figure B-23. Overpressure Plot for Shot 6 at the Turret Right Location

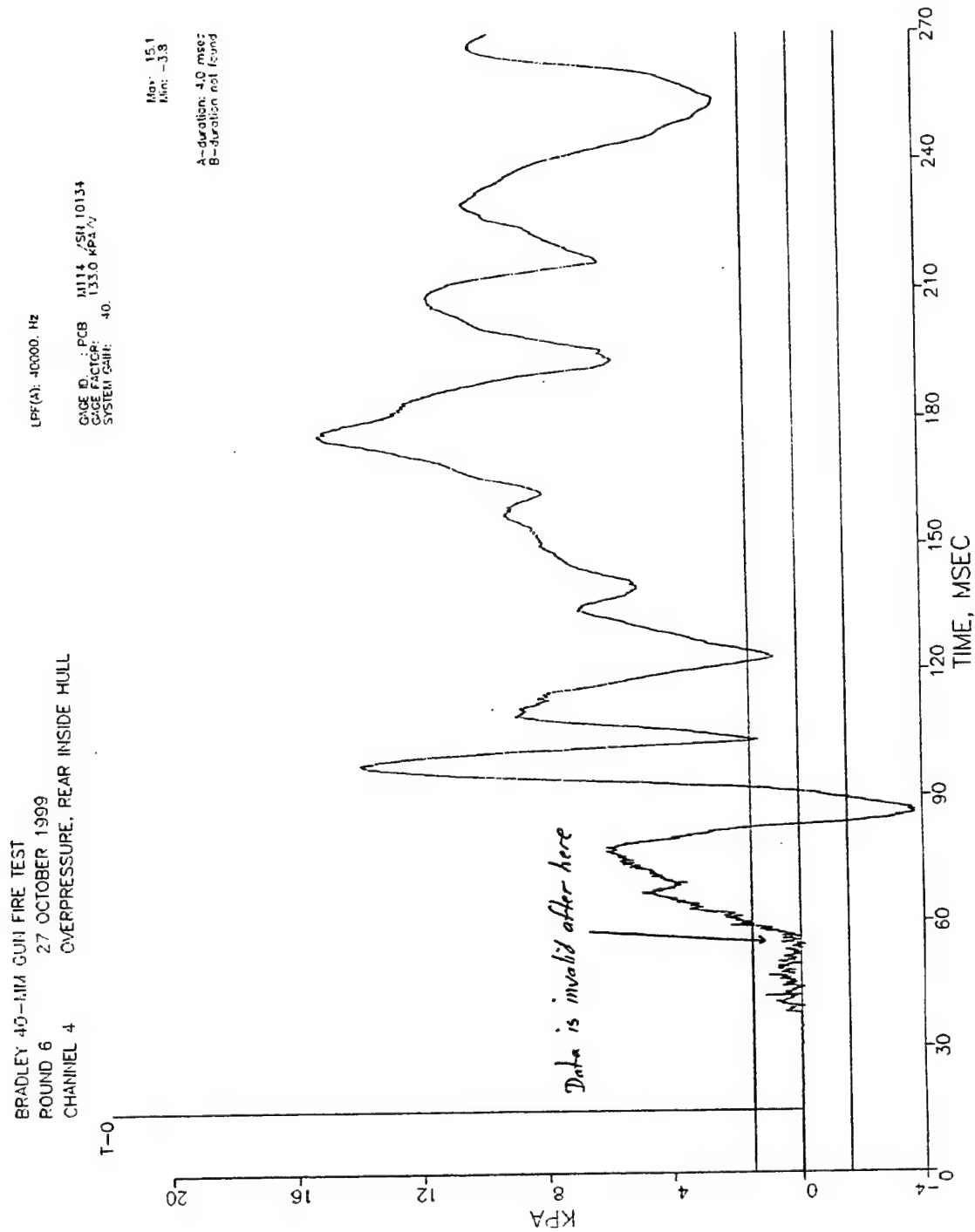


Figure B-24. Overpressure Plot for Shot 6 at the Rear Crew Area Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 7 27 OCTOBER 1999
 CHANNEL 1 OVERPRESSURE, DRIVER

LPT(A): 40000. Hz

GAGE ID.: PCB M114 /SN 4331
 GAGE FACTOR: 105.1 KPA/V
 SYSTEM GAIN: 100.

Max: 1.7
 Min: -1.1

A-duration: 3 msec
 B-duration: 140.4 msec
 Max. pressure/dy: 1216
 x gnd's rising protection

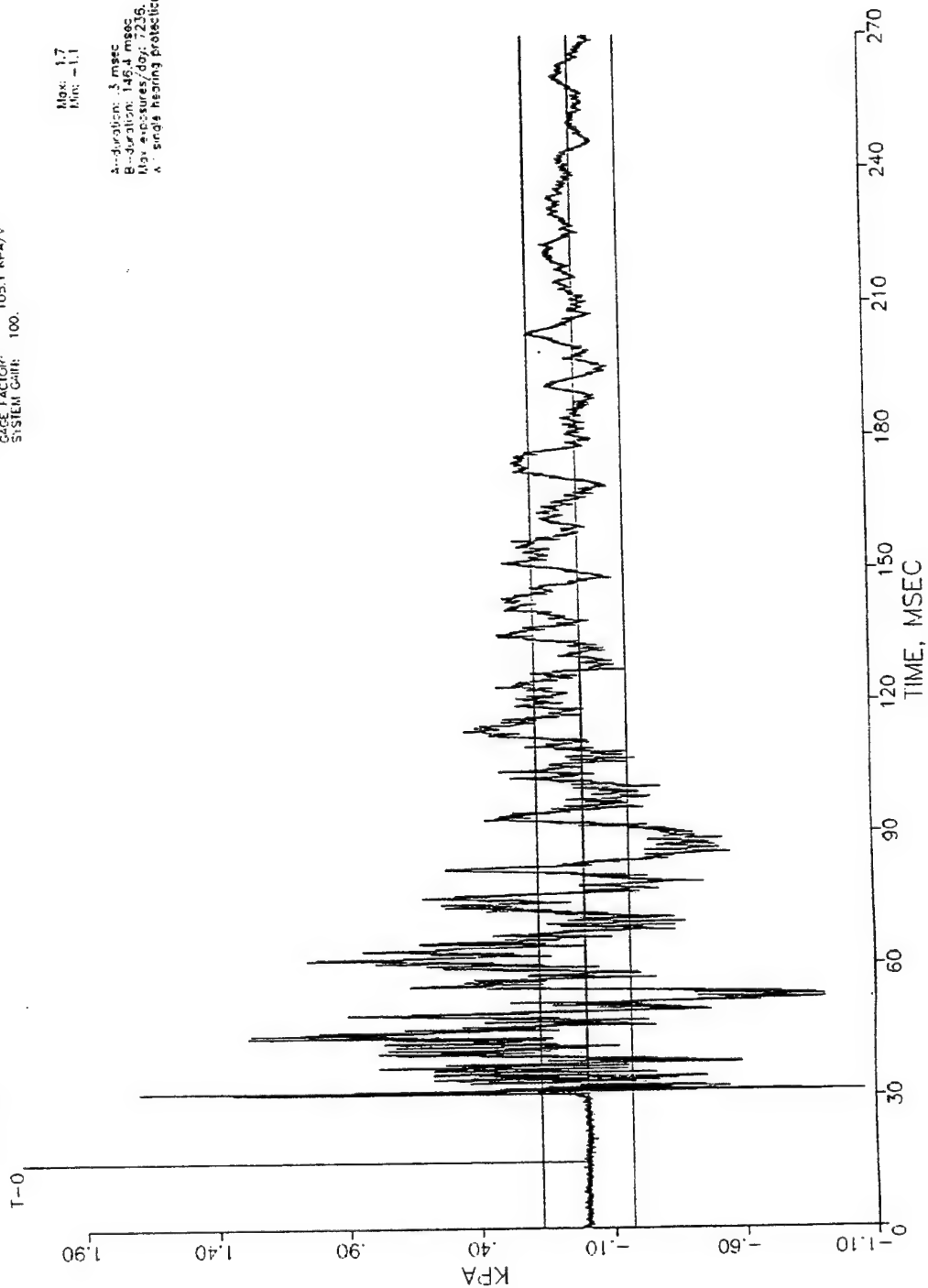


Figure B-25. Overpressure Plot for Shot 7 at the Driver Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 7 27 OCTOBER 1999
 CHANNEL 2 OVERPRESSURE, TURRET LEFT

LPF(A): 40000 Hz

CASE ID: PCB M114 /304 J333
 CODE FACTOR: 112.6 KPA/V
 SYSTEM GAIN: 100

Max: 2.7
 Min: -3.9

A-duration: 3.1 msec
 B-duration: 105.5 msec
 Max exposures/day: 16da
 w/ single hearing protection

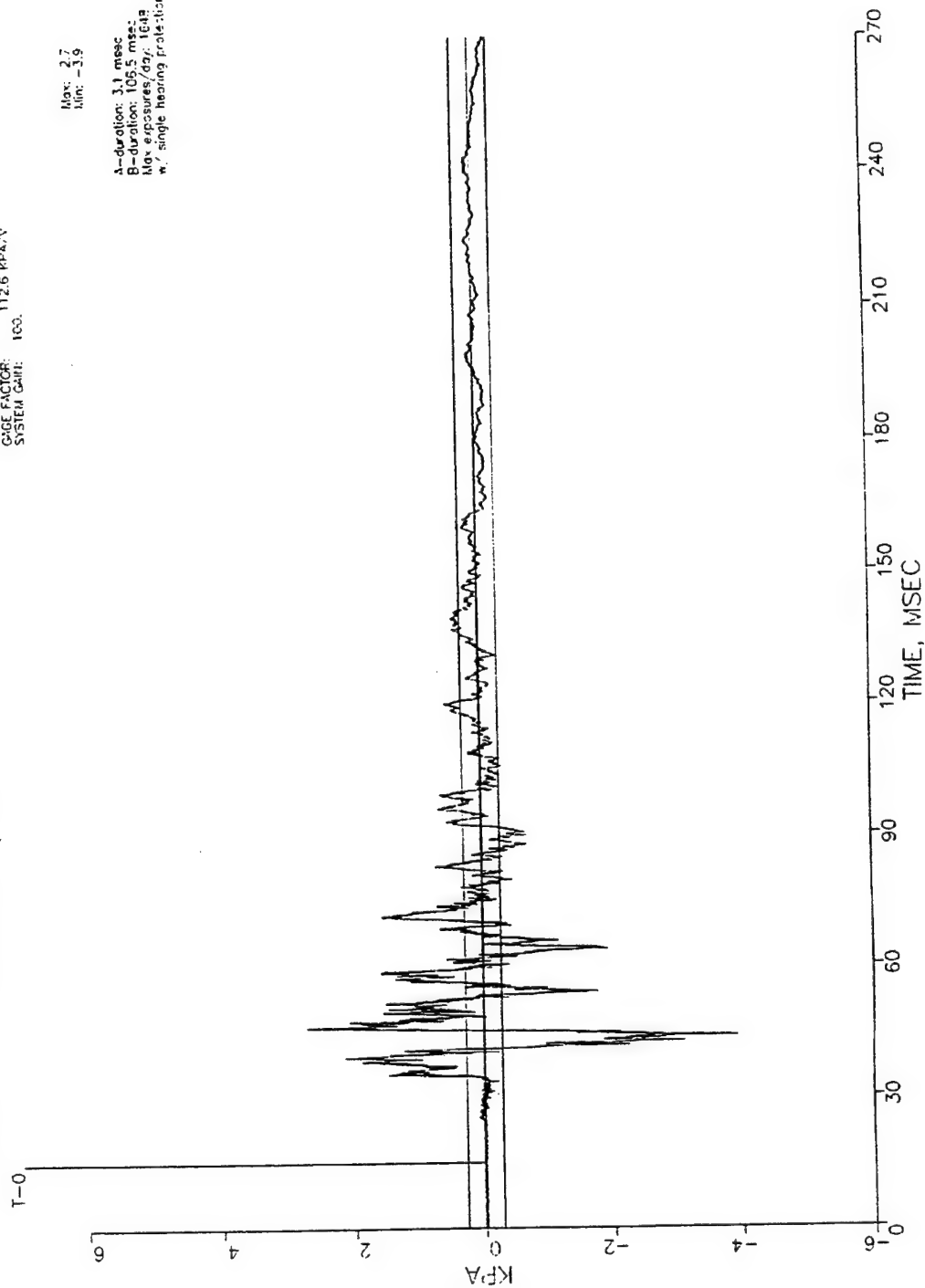


Figure B-26. Overpressure Plot for Shot 7 at the Turret Left Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 7 27 OCTOBER 1999
 CHANNEL 3 OVERPRESSURE, TURRET RIGHT

LPF(A): 40000. Hz

GAGE ID: PCB M114 /SN 10136
 GAGE FACTOR: 126.9 KPA/V
 SYSTEM GAIN: 150.

Max: 3.5
 Min: -3.1

A-duration: 4.1 msec
 B-duration: 107.3 msec
 Max exposure: 10/15/12
 w/ single hearing protection

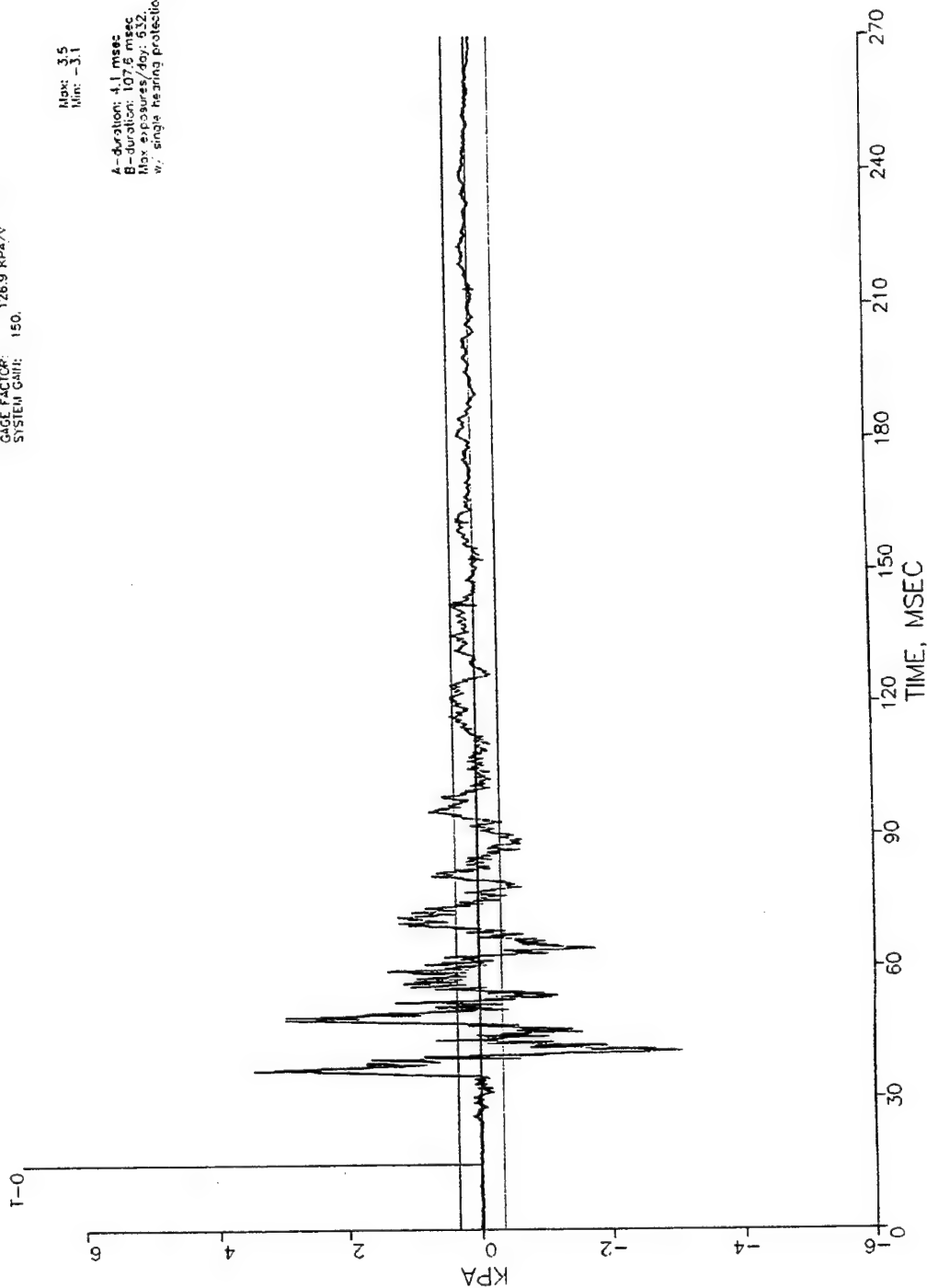


Figure B-27. Overpressure Plot for Shot 7 at the Turret Right Location

BRADLEY 40- LHM GUN FIRE TEST
 ROUND 7 27 OCTOBER 1999
 CHANNEL 4 OVERPRESSURE, REAR INSIDE HULL

LPR(A): 10000. HZ

GAGE ID.: PCB M114 54.4989
 GAGE FACTOR: 106.1 kPa/V
 SYSTEM GAIN: 40.

Max: 931
 Min: -2.215

Duration: 2.1 msec
 Rise time: 200.0 msec
 Max. pressure/dy: 53535.
 A: single hearing protection

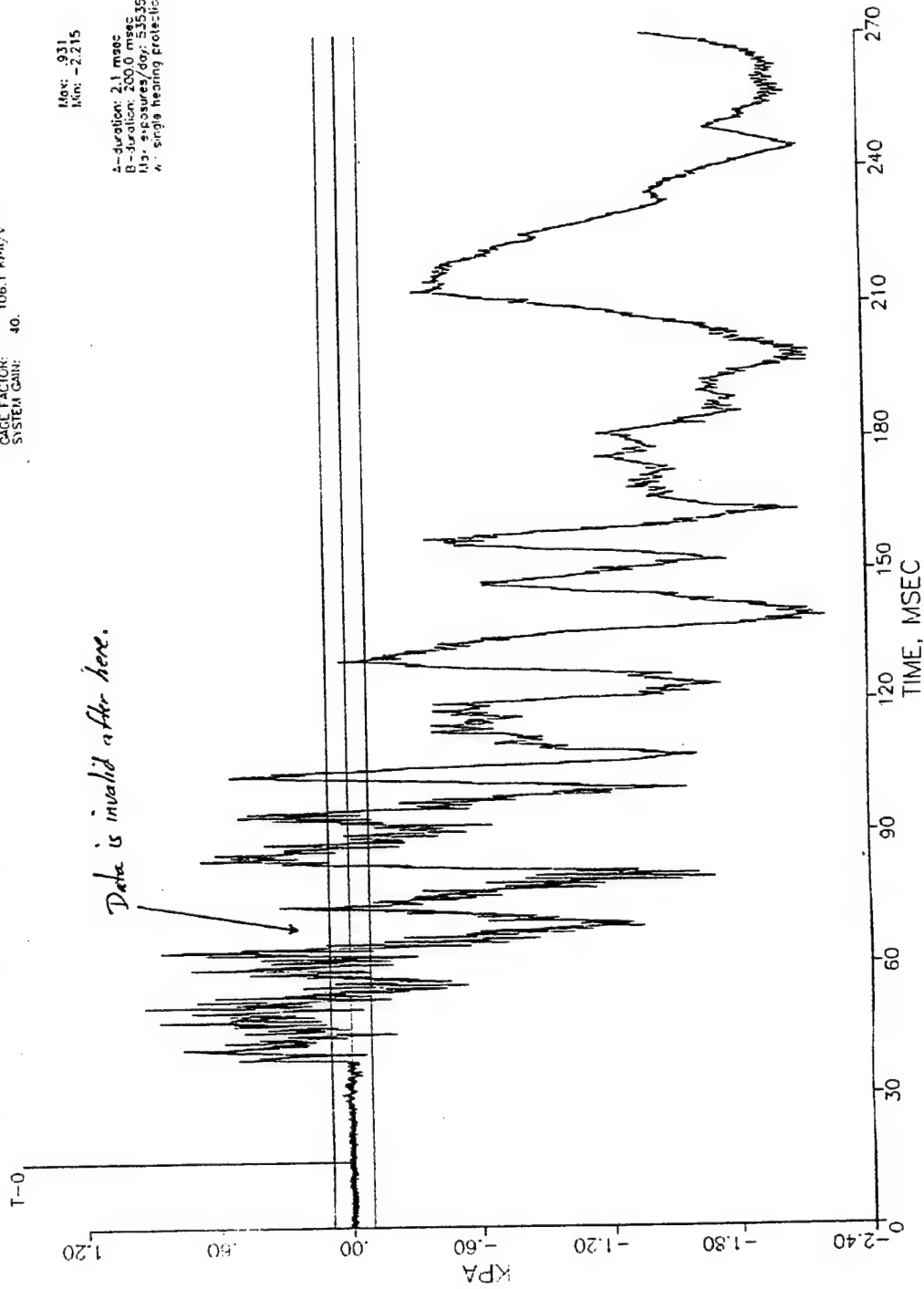


Figure B-28. Overpressure Plot for Shot 7 at the Rear Crew Area Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 8 27 OCTOBER 1999
 CHANNEL 1 OVERPRESSURE, DRIVER

LPT(A) 40000. Hz

GAGE ID: PCB M114 /SN 4331
 GAGE FACTOR: 105.1 KPA/V
 SYSTEM GAIN: 100

Max: 1.4
 Min: -1.0

A-duration: 9 msec
 B-duration: 174.8 msec
 Max. exposure: 39.10994
 A: single feeding protection

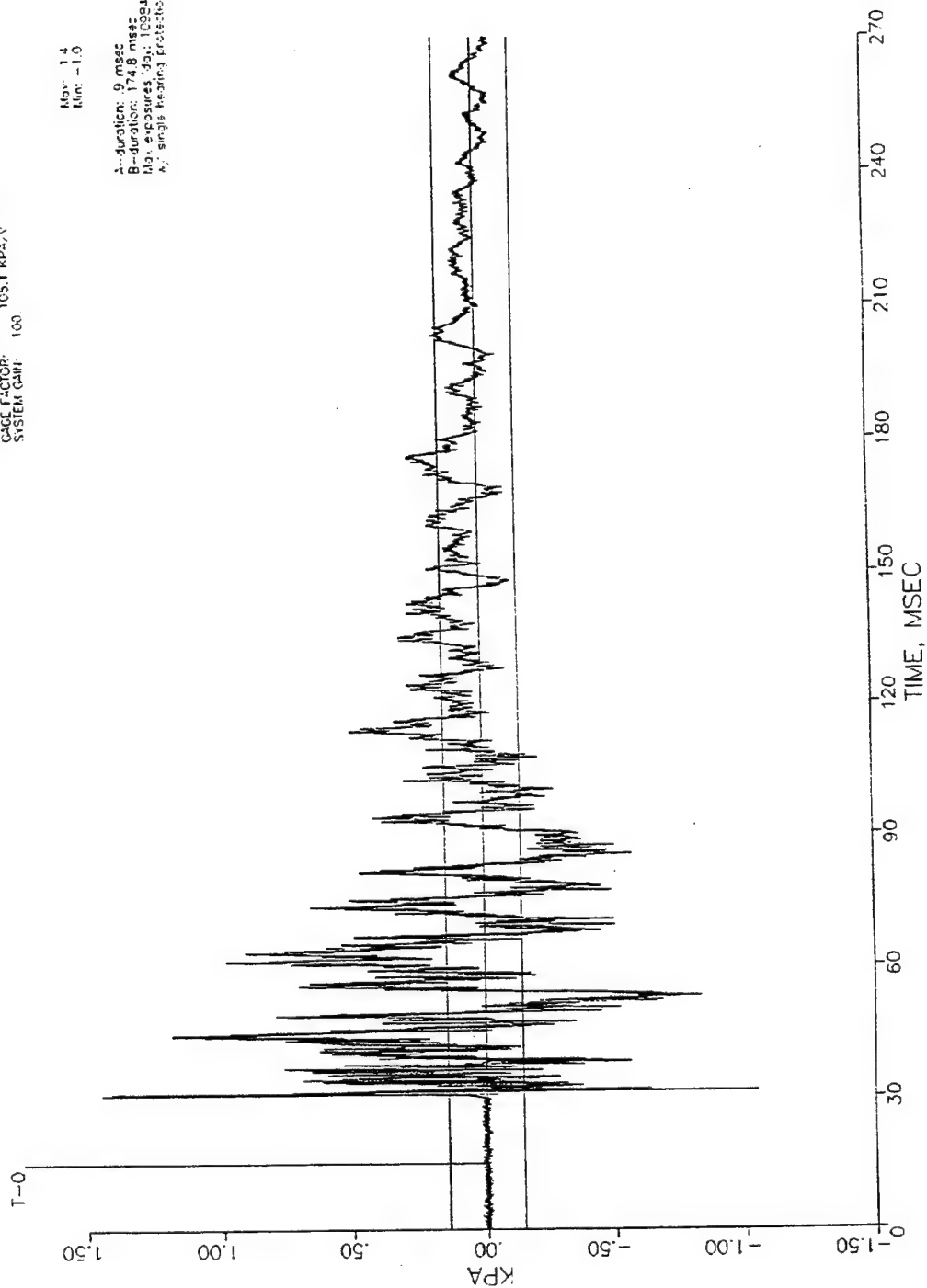


Figure B-29. Overpressure Plot for Shot 8 at the Driver Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 8 27 OCTOBER 1999
 CHANNEL 2 OVERPRESSURE, TURRET LEFT

LPT(A): 40000. Hz

GAGE ID: PCB M114 /SN 4333
 GAGE FACTOR: 112.6 KPA/V
 SYSTEM GAIN: 100

Max: 3.1
 Min: -4.0

A-duration: 8.1 msec
 B-duration: 125.9 msec
 Max. exposure/day: 830.
 A: single hearing protection

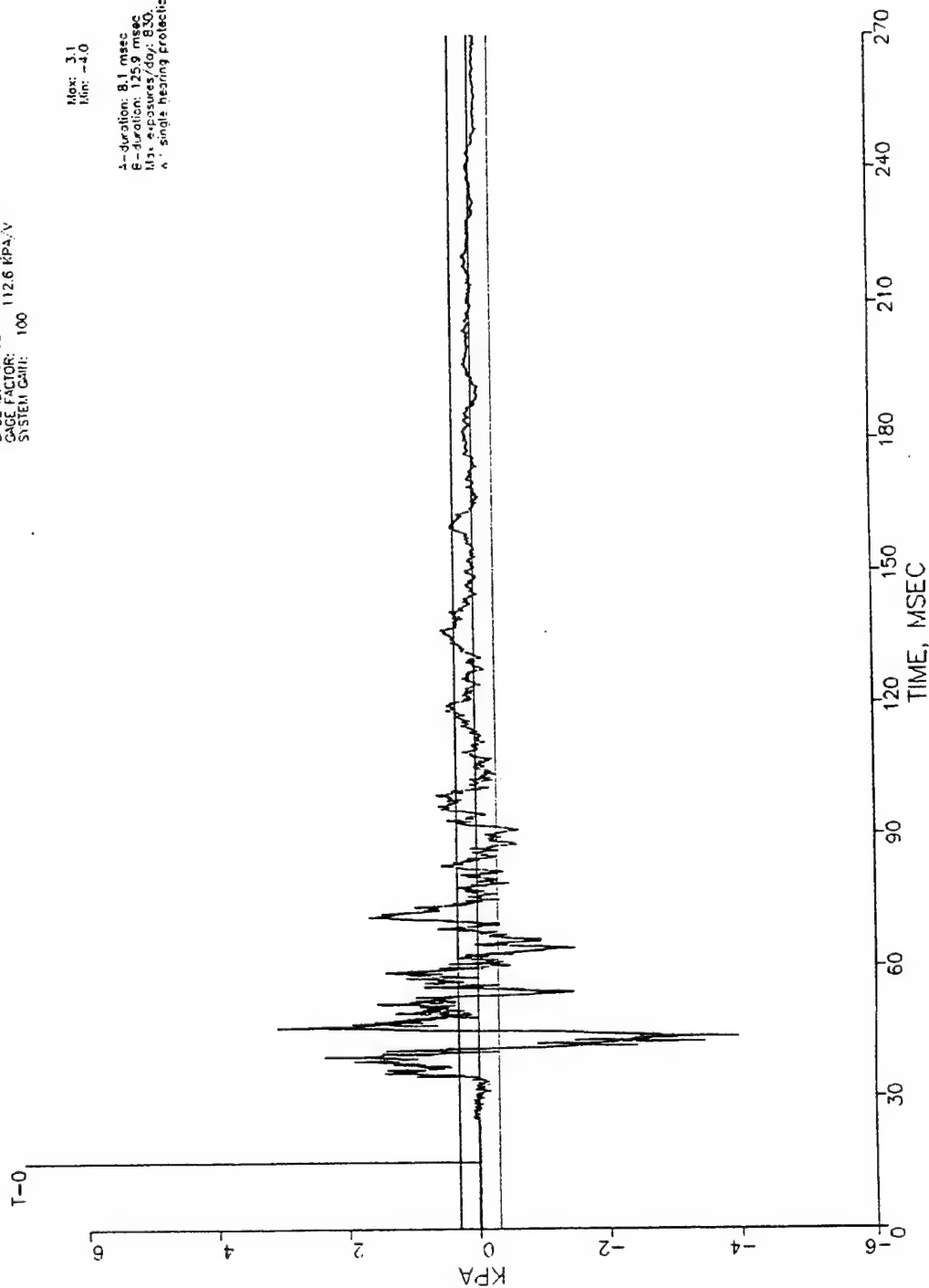


Figure B-30. Overpressure Plot for Shot 8 at the Turret Left Location

BRADLEY 40-MIL GUN FIRE TEST
 ROUND 8 27 OCTOBER 1999
 CHANNEL 3 OVERPRESSURE, TURRET RIGHT

LPF(A): 40000. Hz

GAGE ID: 1 PCB M114 /SN 12126
 GAGE FACTOR: 1269 KPA/V
 SYSTEM GAIN: 150.

Max: 3.4
 Min: -2.9

A-duration: 4.0 msec
 B-duration: 64.5 msec
 Max exposure/dop: 1339
 N / angle heading protection

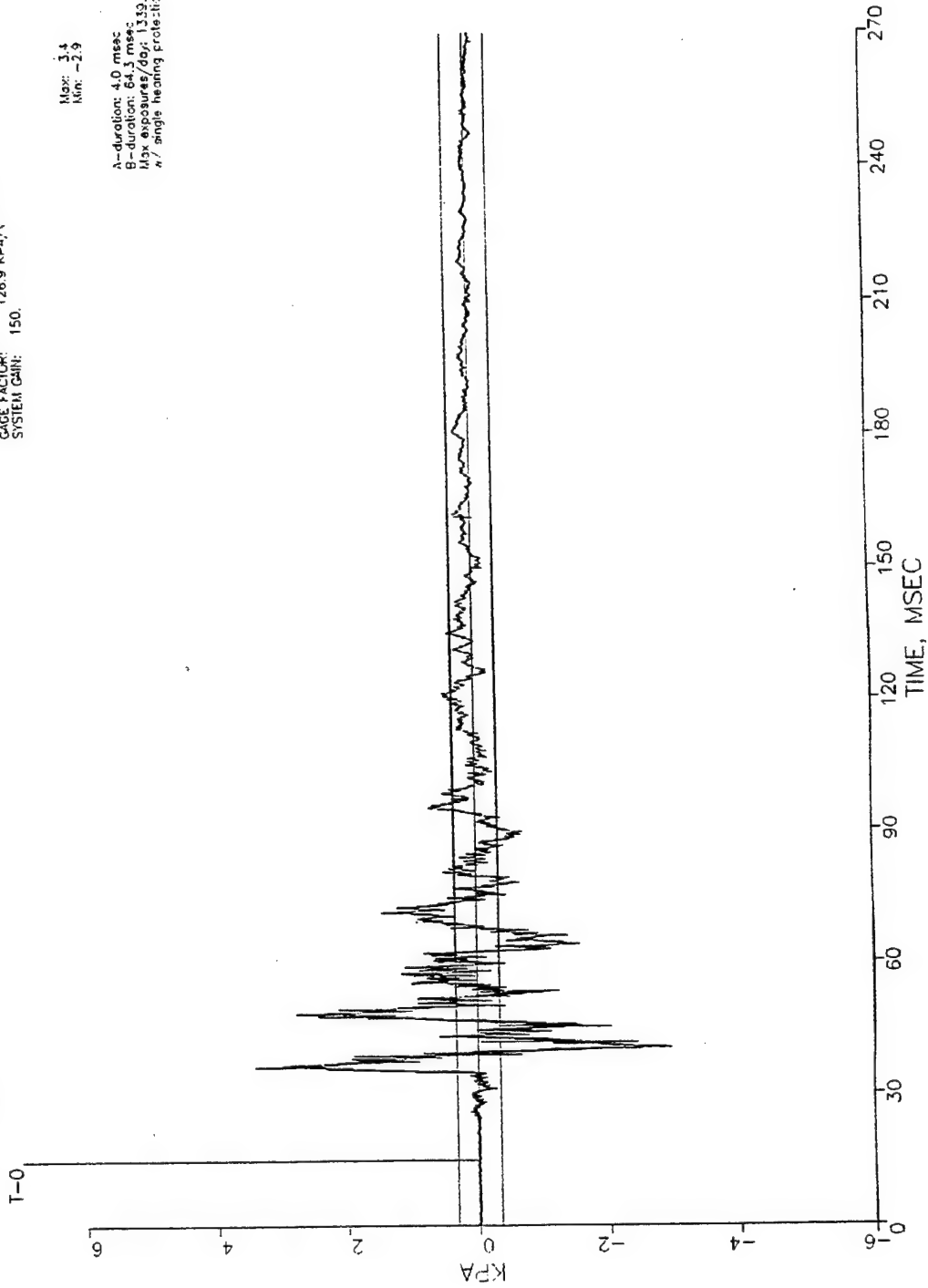


Figure B-31. Overpressure Plot for Shot 8 at the Turret Right Location

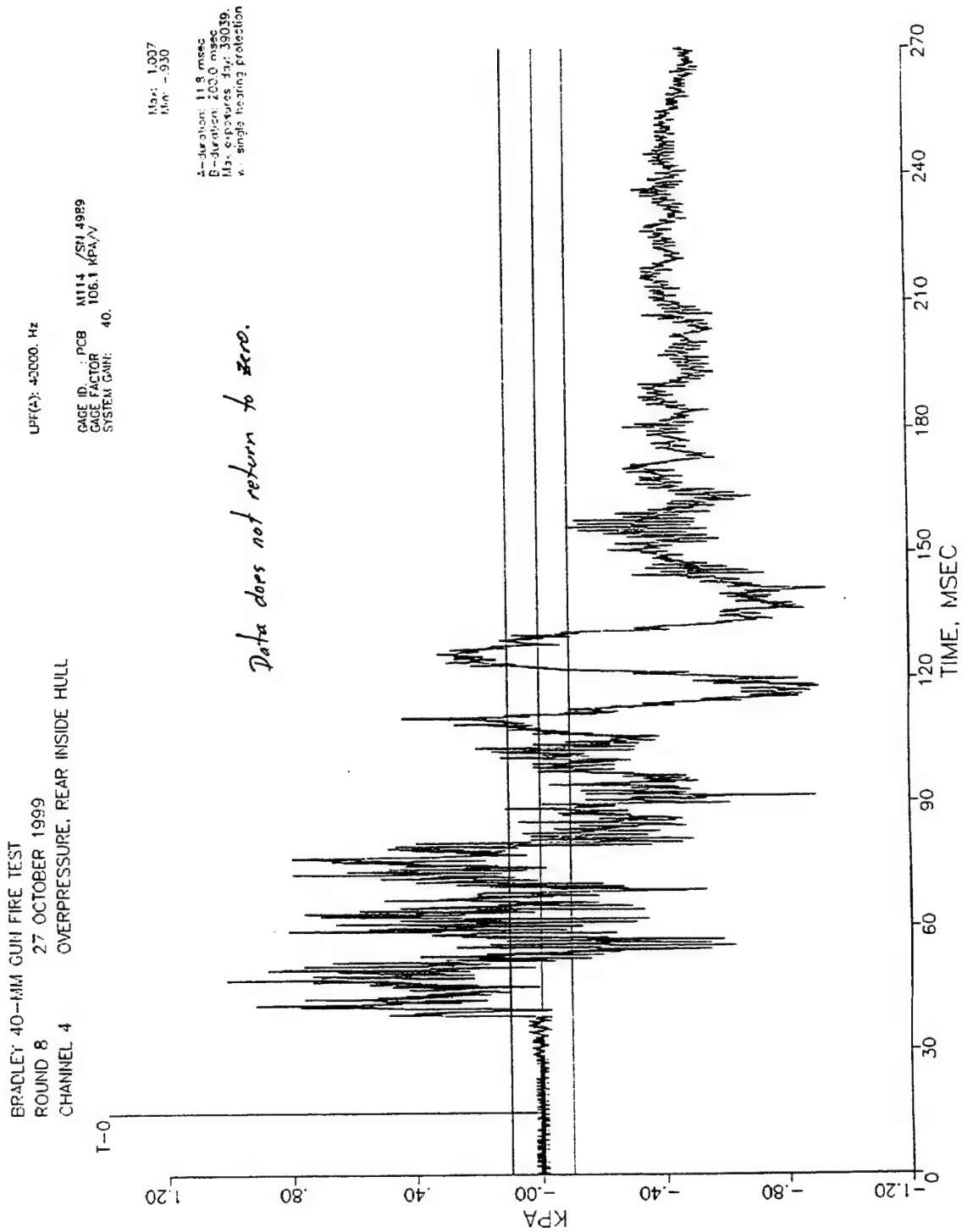


Figure B-32. Overpressure Plot for Shot 8 at the Rear Crew Area Location

BRADLEY 40-MM GUH FIRE TEST
 ROUND 9 27 OCTOBER 1999
 CHANNEL 1 OVERPRESSURE, DRIVER

LPF(A): 40000. Hz

GAGE ID: PCB M114 /S/1 4331
 GAGE FACTOR: 105.1 KPA V
 SYSTEM GAIN: 100.

Max: 1.6
 Min: -1.1

A-duration: 3 msec
 B-duration: 146.1 msec
 Max exposures/day: 10175.
 a. single heating protection

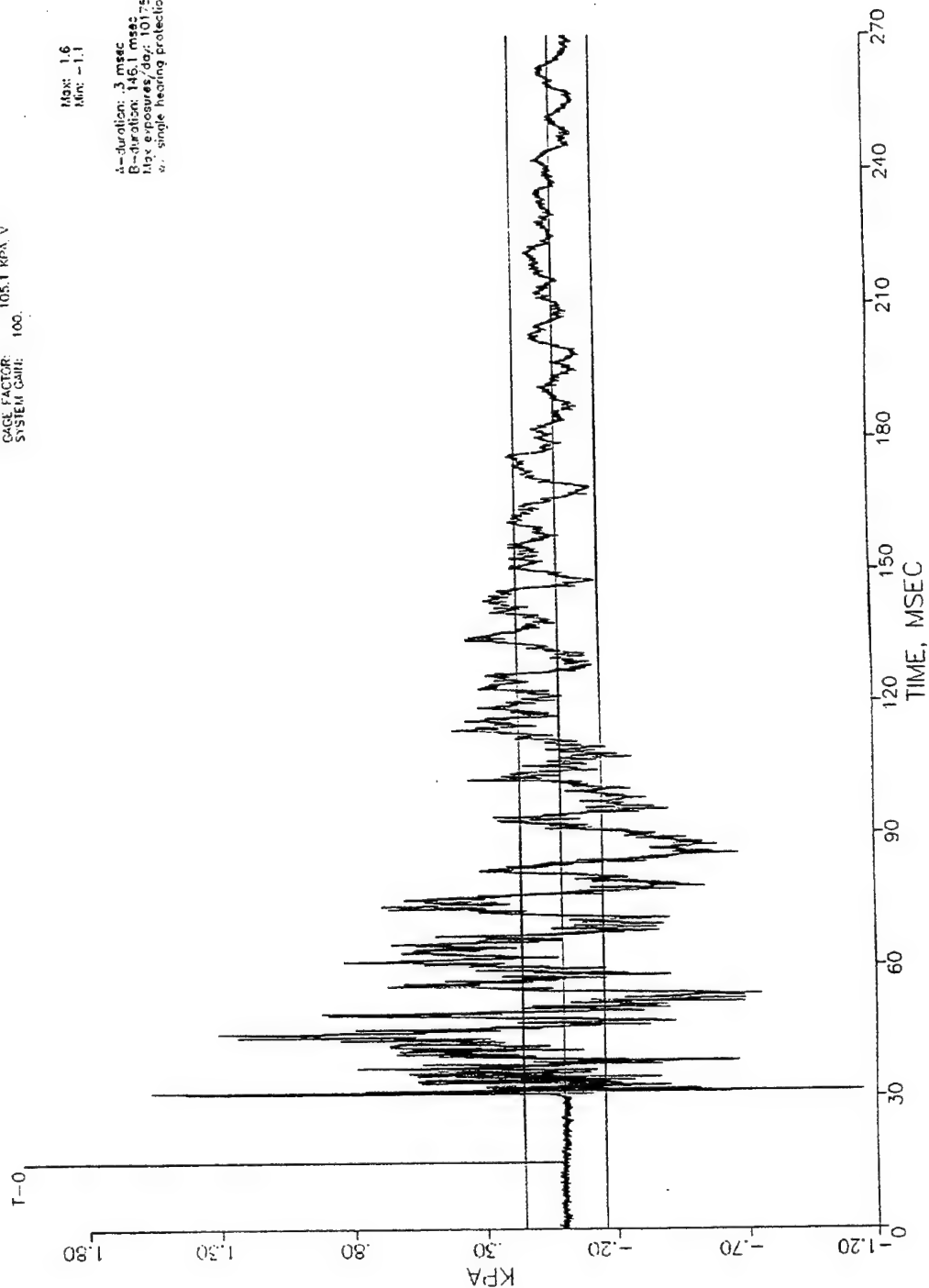


Figure B-33. Overpressure Plot for Shot 9 at the Driver Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 9
 CHANNEL 2 OVERPRESSURE, TURRET LEFT

LPT(A): 10000. Hz

GAGE ID: PCB M114 /SH-4333
 GAGE FACTOR: 112.6 KPA/V
 SYSTEM GAIN: 100.

Max: 3.0
 Min: -3.5

A-duration: 3.7 msec
 B-duration: 105.9 msec
 Max exposures/day: 1122.
 w/ single hearing protection

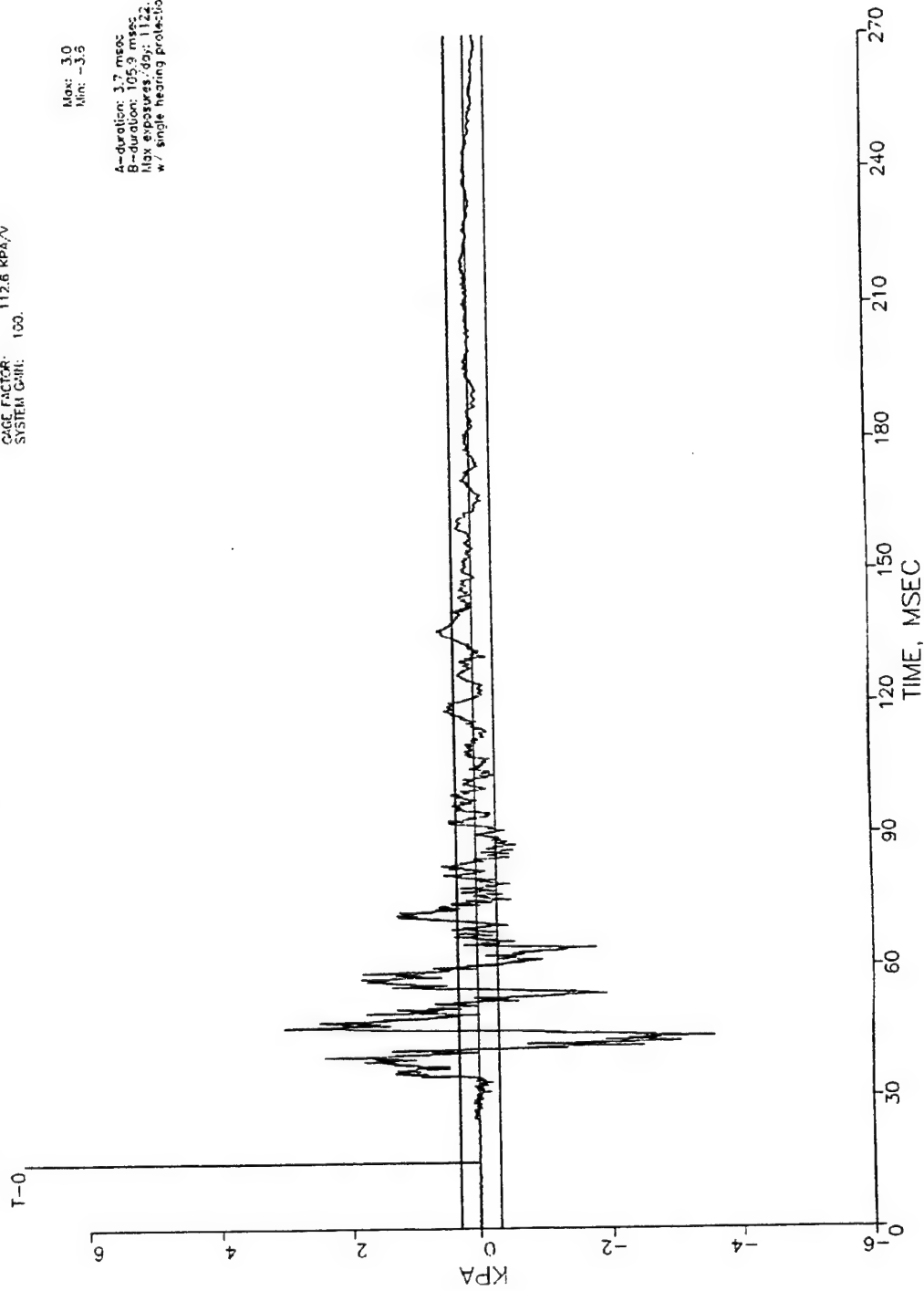


Figure B-34. Overpressure Plot for Shot 9 at the Turret Left Location

BRADLEY 40-LIM GUH PIPE TEST
 ROUND 9 27 OCTOBER 1999
 CHANNEL 3 OVERPRESSURE, TURRET RIGHT

LFF(A): 40000. Hz

CAGE ID: PCB M111 /SU10136
 GAGE FACTOR: 126.9 KPA/V
 SYSTEM GAIN: 150.

Max: 3.5
 Min: -3.3

A-duration: 4.1 msec
 B-duration: 63.4 msec
 Max. exposure/day: 1254.
 A: single hearing protection

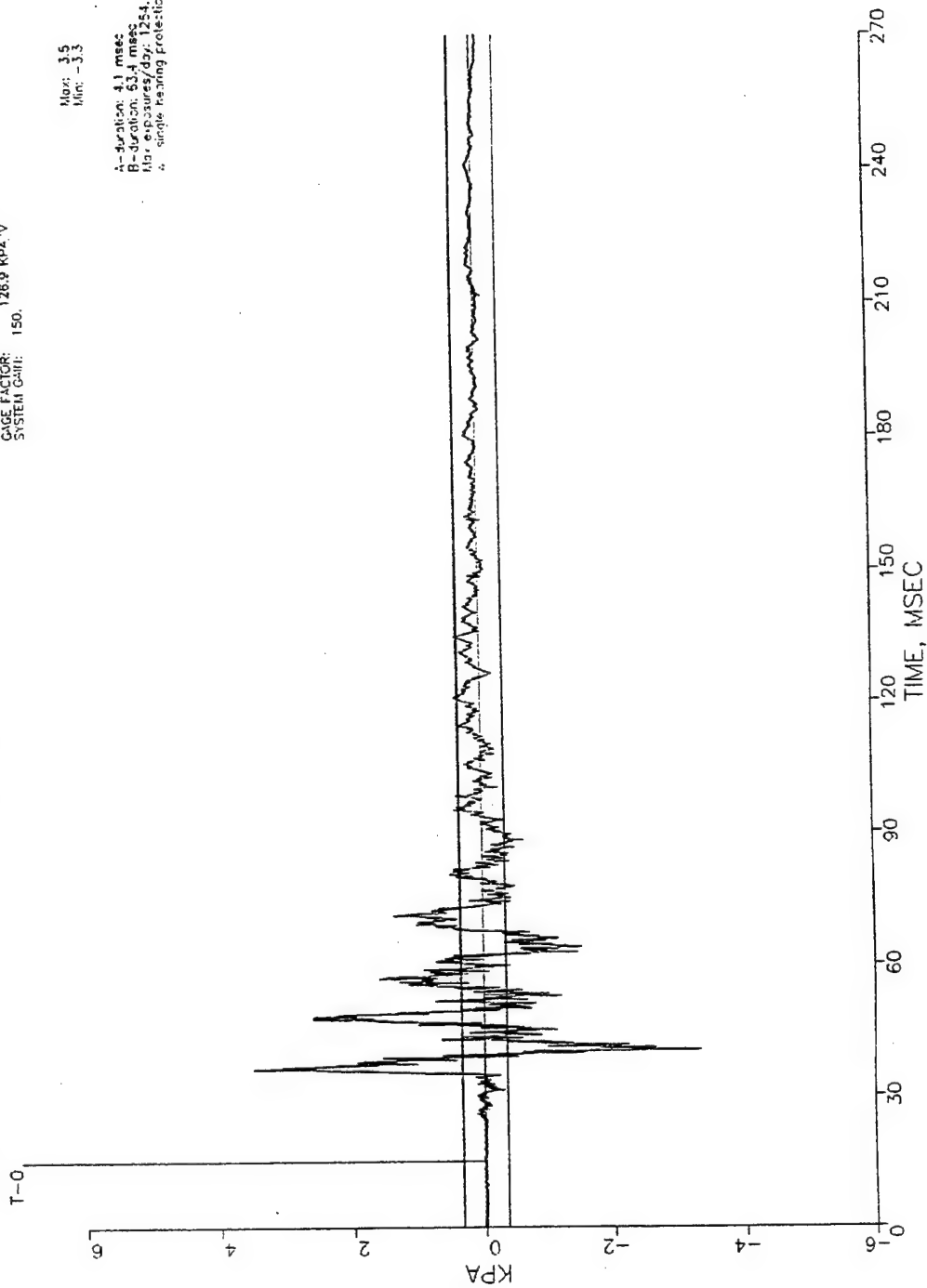


Figure B-35. Overpressure Plot for Shot 9 at the Turret Right Location

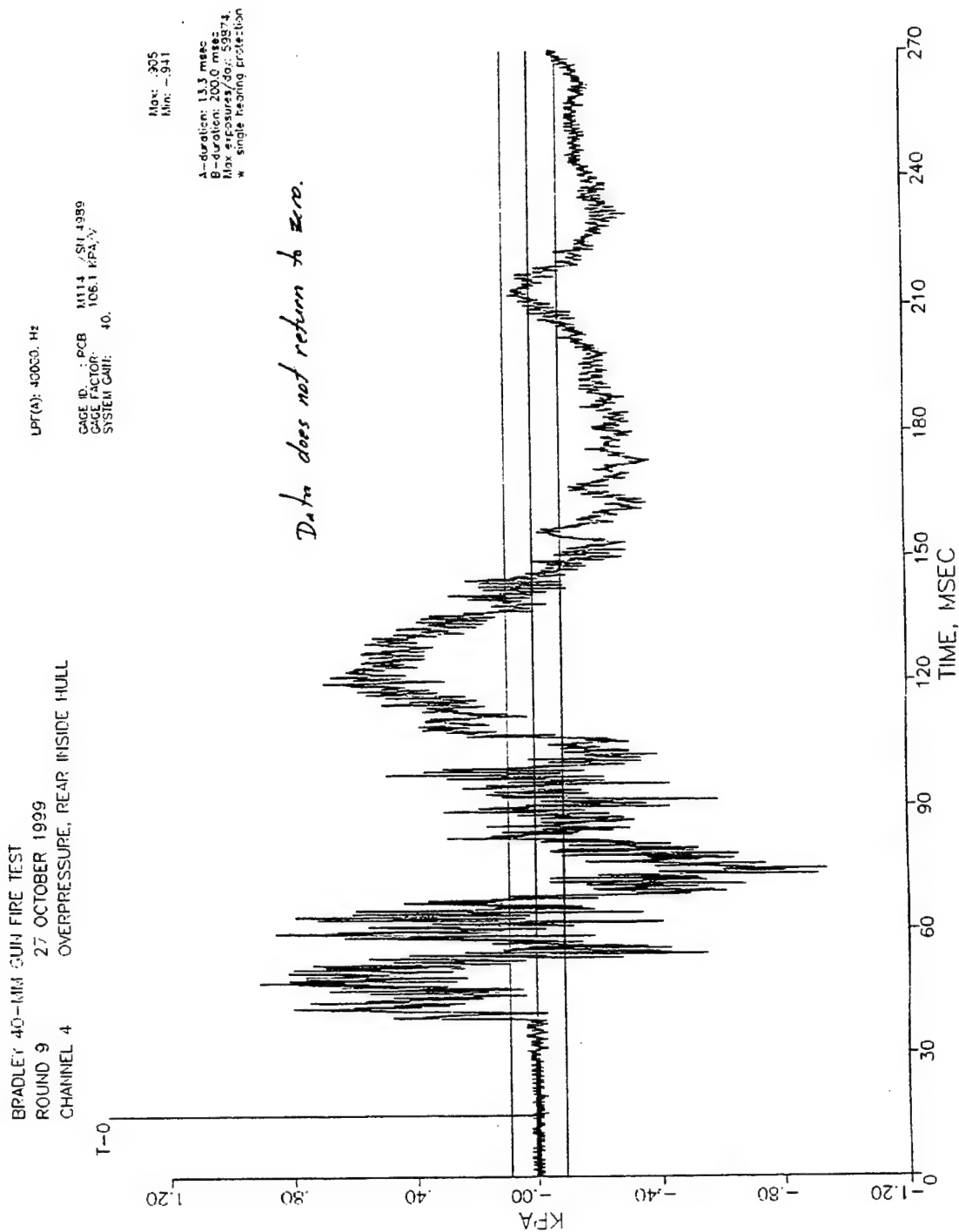


Figure B-36. Overpressure Plot for Shot 9 at the Rear Crew Area Location

BRADLEY 40-MM GUM FIRE TEST
 ROUND 10 27 OCTOBER 1999
 CHANNEL 1 OVERPRESSURE, DRIVER

LPF(A): 40000. Hz

GAGE ID.: PCB M114 /SN 4331
 GAGE FACTOR: 105.1 KPA/V
 SYSTEM GAIN: 100.

Max: 1.508
 Min: -.869
 A-duration: 3 msec
 B-duration: 146.3 msec
 Max exposure/day: 11777.
 w/ single hearing protection

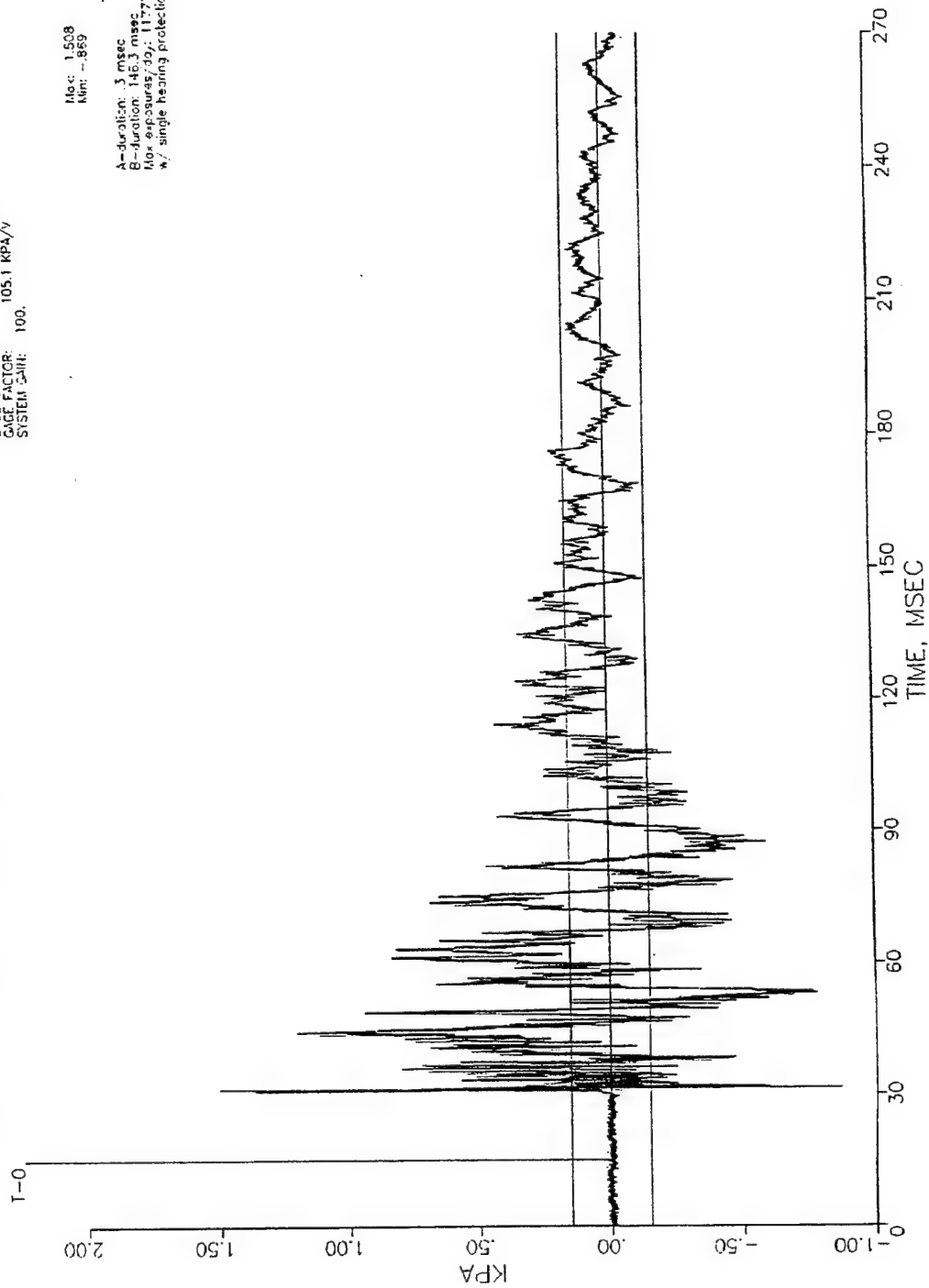


Figure B-37. Overpressure Plot for Shot 10 at the Driver Location

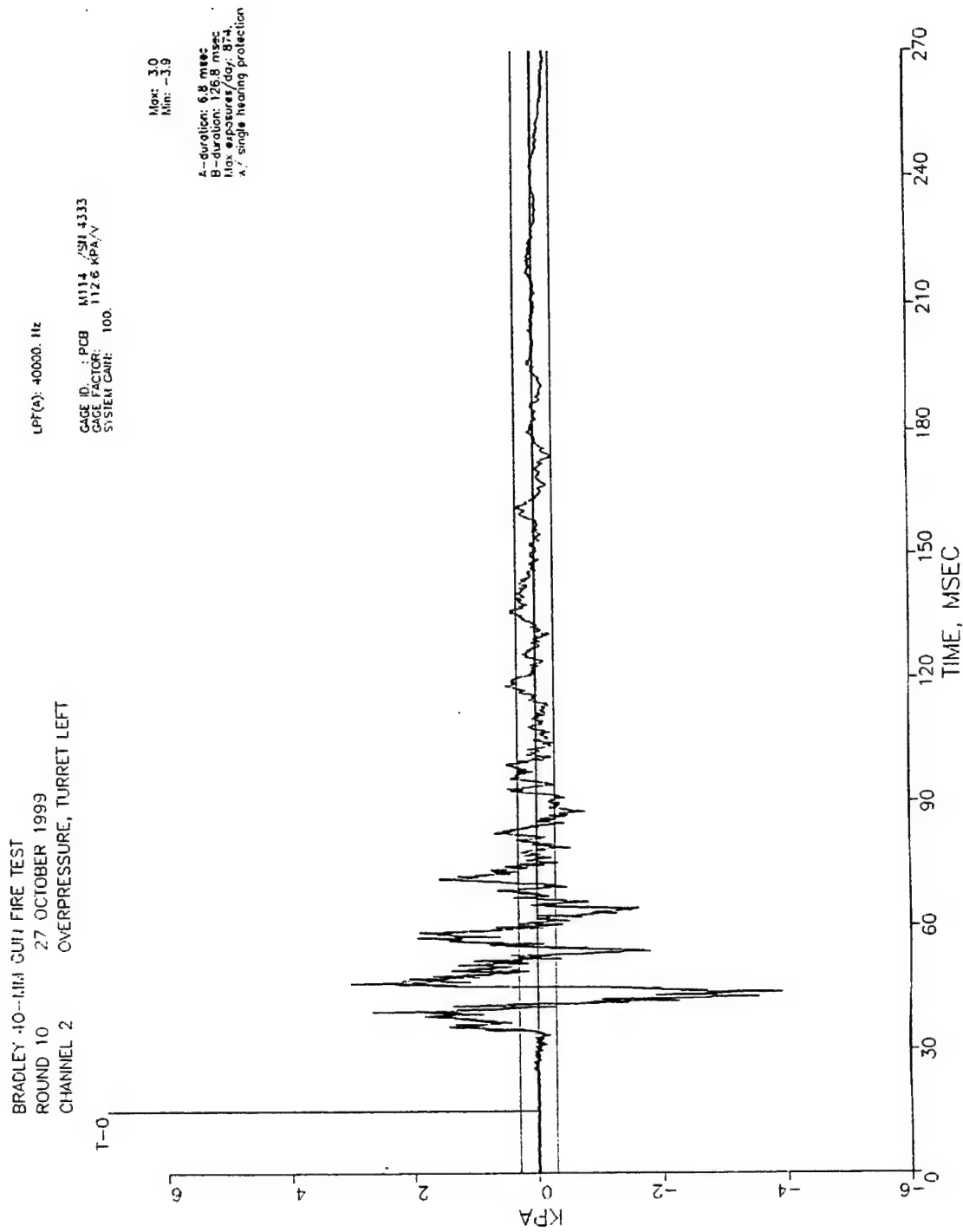


Figure B-38. Overpressure Plot for Shot 10 at the Turret Left Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 10 27 OCTOBER 1999
 CHANNEL 3 OVERPRESSURE, TURRET RIGHT

LPT(A): 40000. Hz

GAGE ID.: PCB 11114 /SN 10136
 GAGE FACTOR: 126.9 KPA/V
 SYSTEM GAIN: 150.

Max: 3.4
 Min: -3.4
 A-duration: 1.0 msec
 B-duration: 63.9 msec
 Max exposure/dy: 1323
 w/ single hearing protection

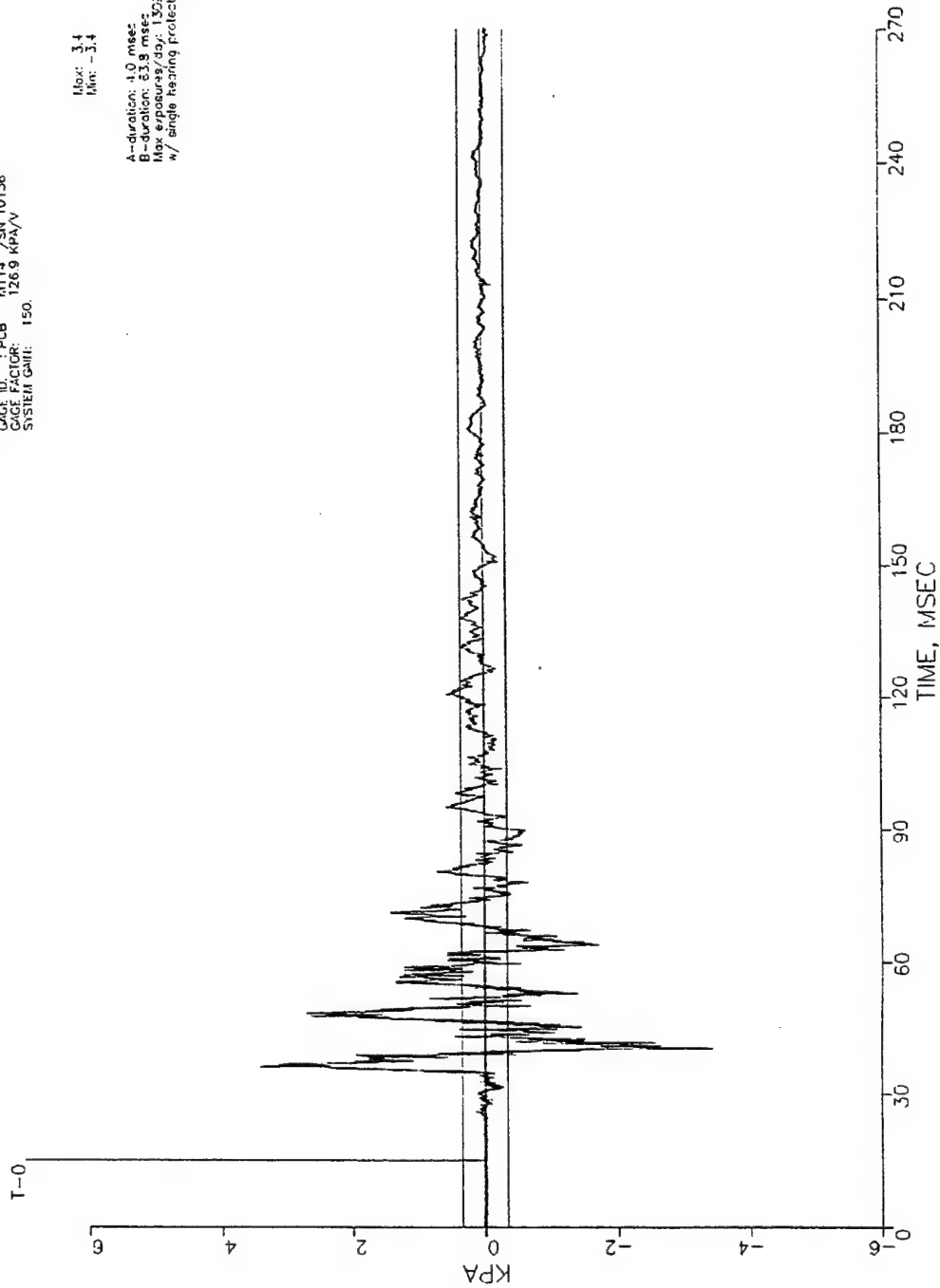


Figure B-39. Overpressure Plot for Shot 10 at the Turret Right Location

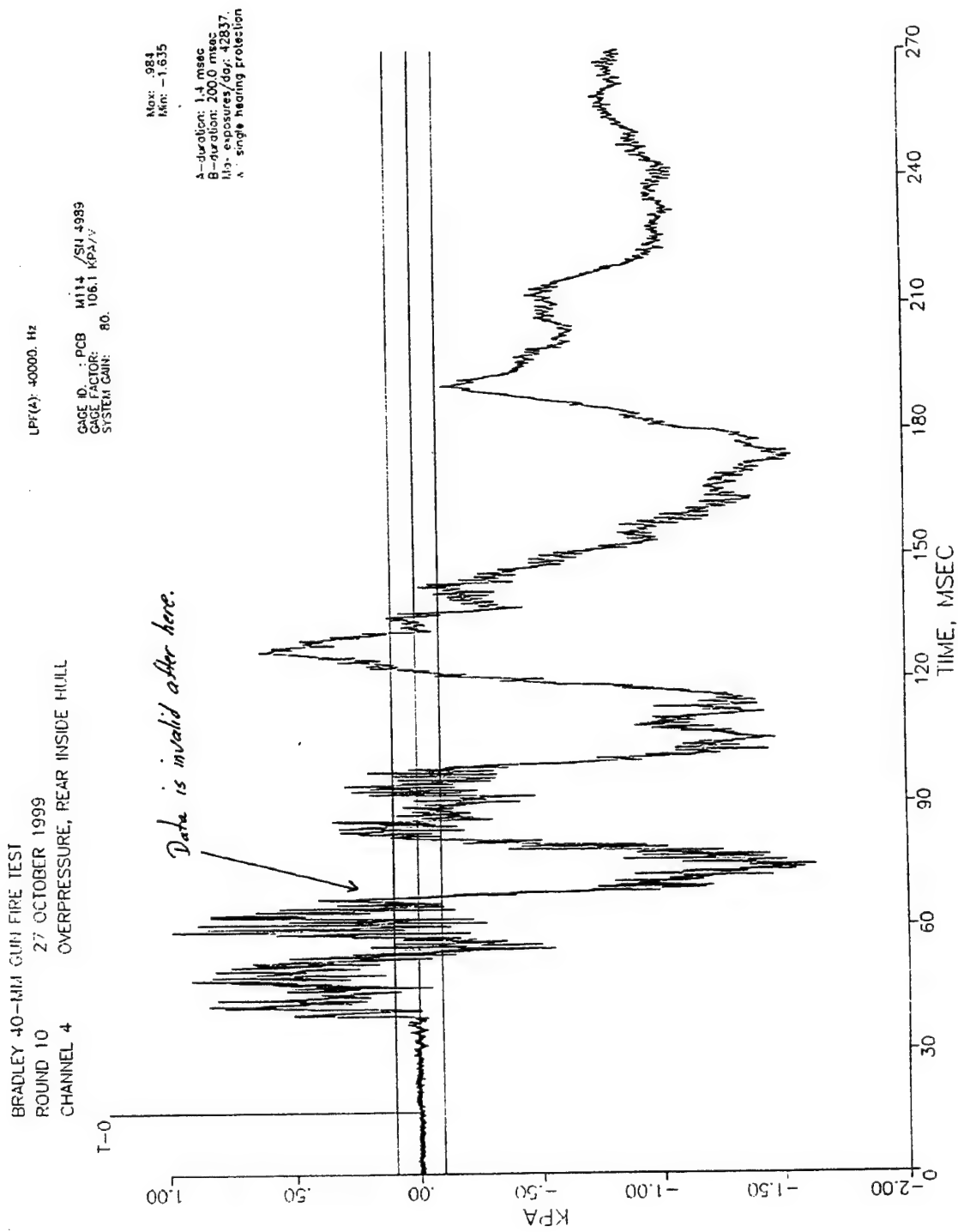


Figure B-40. Overpressure Plot for Shot 10 at the Rear Crew Area Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 11 27 OCTOBER 1999
 CHANNEL 1 OVERPRESSURE, DRIVER

LPF(A): 40000. Hz

GAGE ID: PCB M114 /SH 4331
 GAGE FACTOR: 105.1 KPA/V
 SYSTEM GAIN: 100.

Max: .891
 Min: -.588

A-duration: 7.3 msec
 B-duration: 177.3 msec
 Max exposures/day: 71890.
 w/ single hearing protection

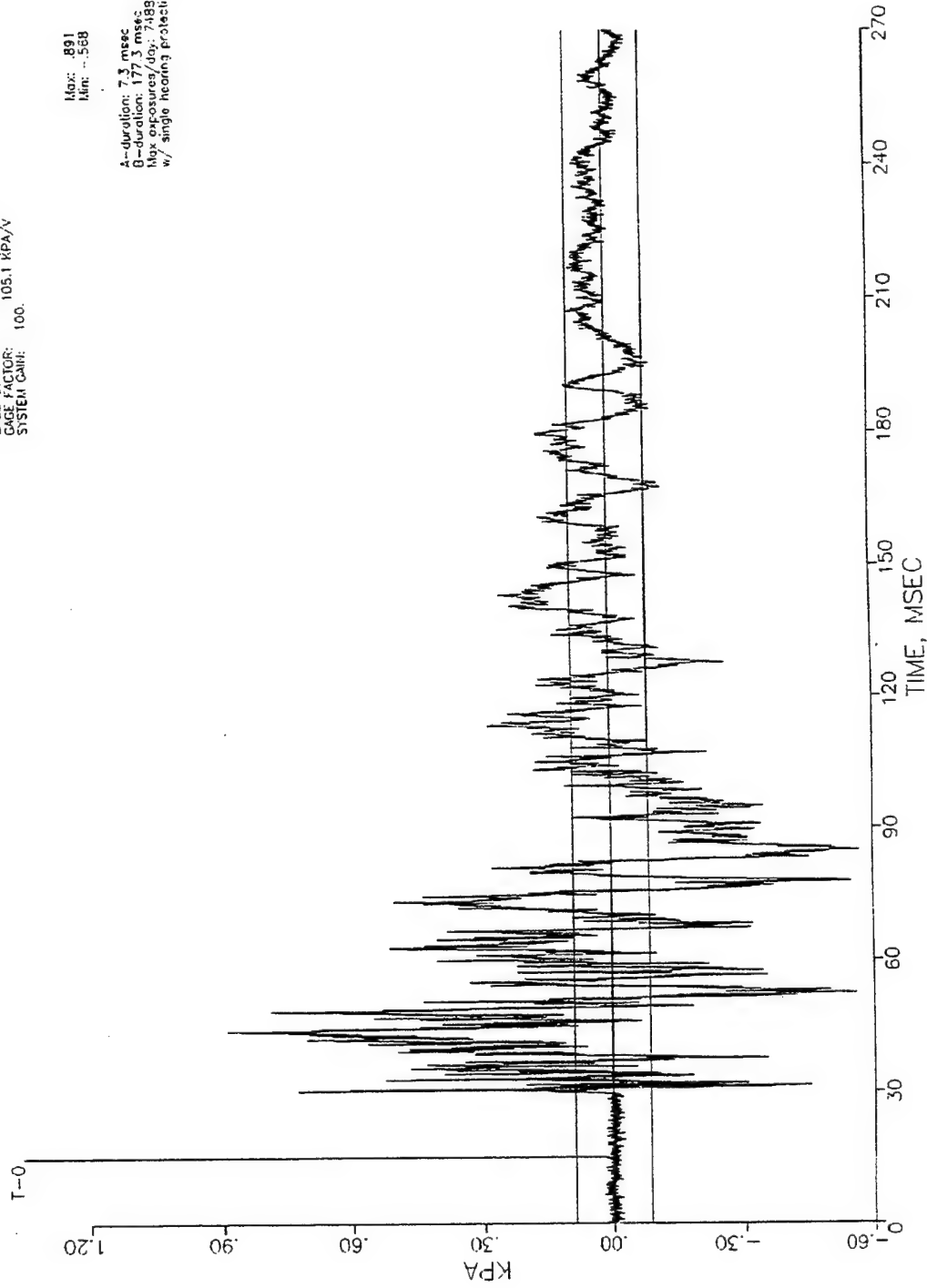


Figure B-41. Overpressure Plot for Shot 11 at the Driver Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 11 27 OCTOBER 1999
 CHANNEL 2 OVERPRESSURE, TURRET LEFT

LPF(A): 40000. Hz

CAGE ID: PCB N114 /SN 4333
 CAGE FACTOR: 112.6 KPA/V
 SYSTEM GAIN: 100.

Max: 3.2
 Min: -2.1

A-duration: 2.8 msec
 B-duration: 55.8 msec
 Max exposures/day: 2075.
 w/ single hearing protection

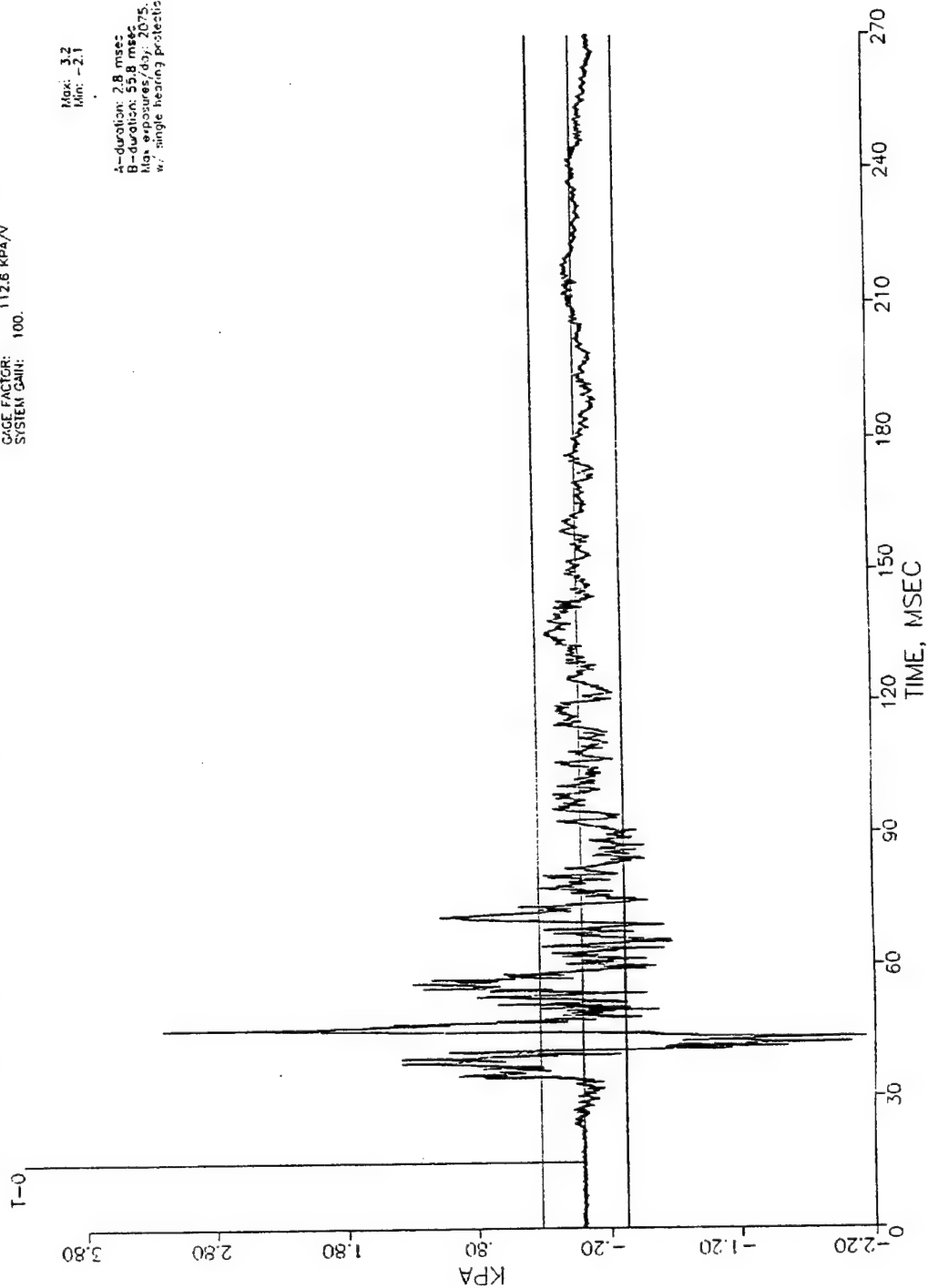


Figure B-42. Overpressure Plot for Shot 11 at the Turret Left Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 11 27 OCTOBER 1999
 CHANNEL 3 OVERPRESSURE, TURRET RIGHT

LPF(A): 40000. Hz

GAGE ID.: PCB M114 /SN 10136
 GAGE FACTOR: 126.9 KPA/V
 SYSTEM GAIN: 150.

Max: 2.3
 Min: -2.2
 A-duration: 4.0 msec
 B-duration: 96.4 msec
 Max exposures/day: 3591
 w: single hearing protection

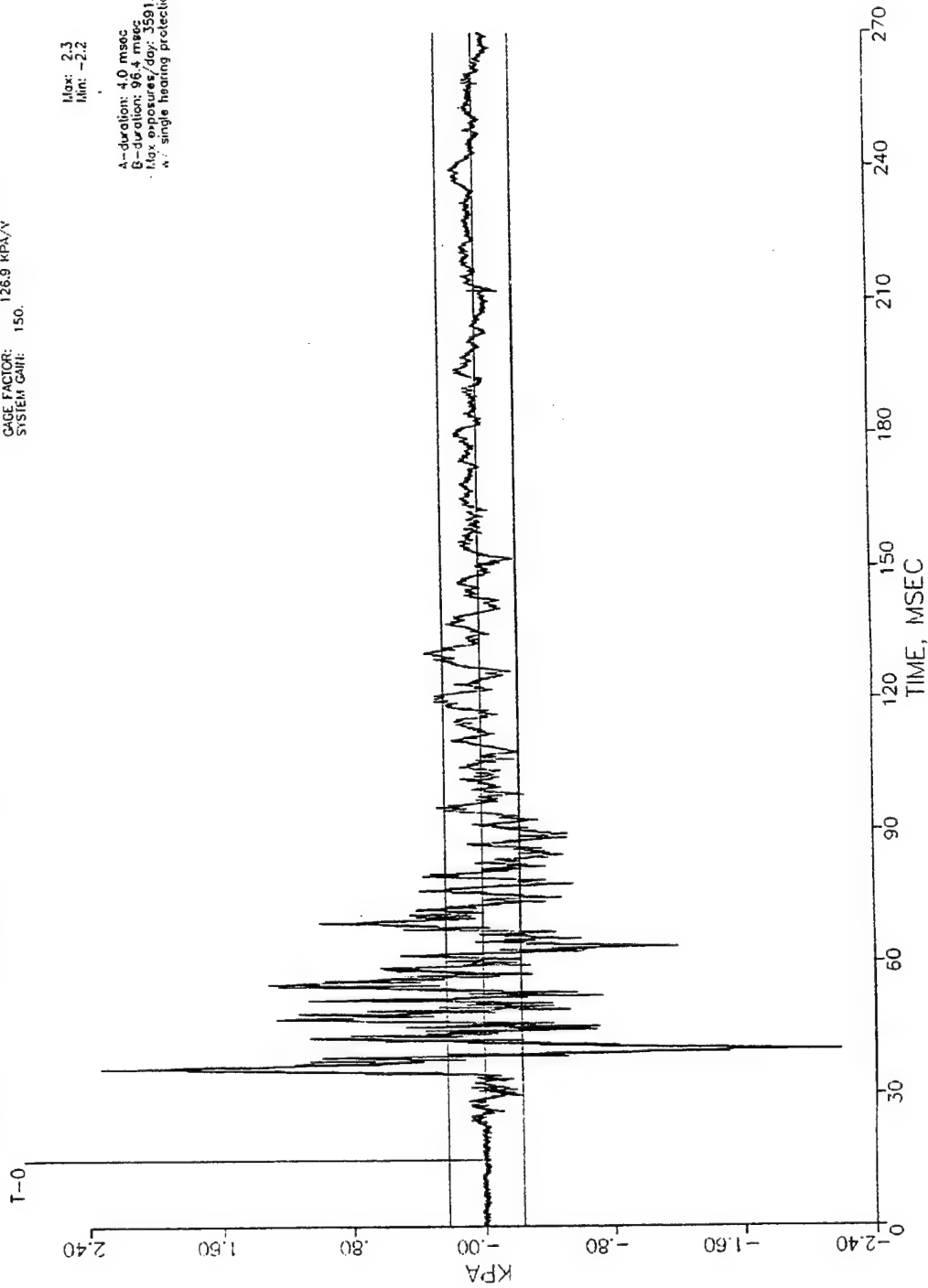


Figure B-43. Overpressure Plot for Shot 11 at the Turret Right Location

BRADLEY 40-MIL GUN FIRE TEST
 ROUND 11 27 OCTOBER 1999
 CHANNEL 4 OVERPRESSURE, REAR INSIDE HULL

LPT(A): 40000. Hz

GAGE ID.: PCB M114 /SI 4989
 GAGE FACTOR: 106.1 KPA/V
 SYSTEM GAIN: 100.

Max: .903
 Min: -.574

A-duration: 14.0 msec
 B-duration: 200.0 msec
 Max exposure: 50452.
 w/ single hearing protection

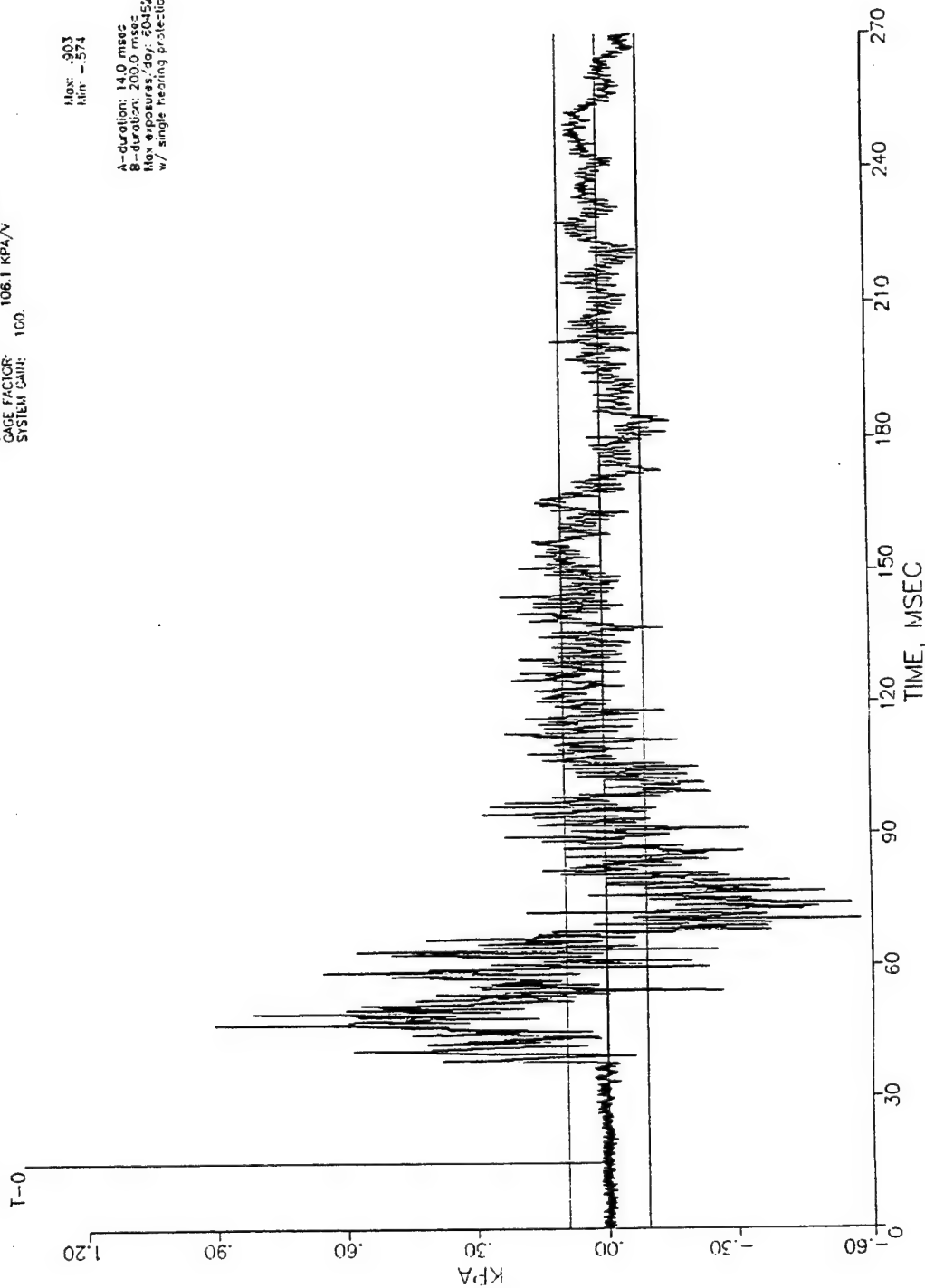


Figure B-44. Overpressure Plot for Shot 11 at the Rear Crew Area Location

BRADLEY 40-LIM GUN FIRE TEST
 ROUND 12 27 OCTOBER 1999
 CHANNEL 1 OVERPRESSURE, DRIVER

LPF(A): 40000. Hz

GAGE ID: 1 PCB M114 /SR1331
 GAGE FACTOR: 105.1 KPA/V
 SYSTEM GAIN: 100.

Max: 1.063
 Min: -.463
 A-duration: 5.0 msec
 B-duration: 18.0 msec
 C-duration: 18.0 msec
 D-duration: 18.0 msec
 E-duration: 18.0 msec
 F-duration: 18.0 msec
 G-duration: 18.0 msec
 H-duration: 18.0 msec
 I-duration: 18.0 msec
 J-duration: 18.0 msec
 K-duration: 18.0 msec
 L-duration: 18.0 msec
 M-duration: 18.0 msec
 N-duration: 18.0 msec
 O-duration: 18.0 msec
 P-duration: 18.0 msec
 Q-duration: 18.0 msec
 R-duration: 18.0 msec
 S-duration: 18.0 msec
 T-duration: 18.0 msec
 U-duration: 18.0 msec
 V-duration: 18.0 msec
 W-duration: 18.0 msec
 X-duration: 18.0 msec
 Y-duration: 18.0 msec
 Z-duration: 18.0 msec
 a/ single heating protection

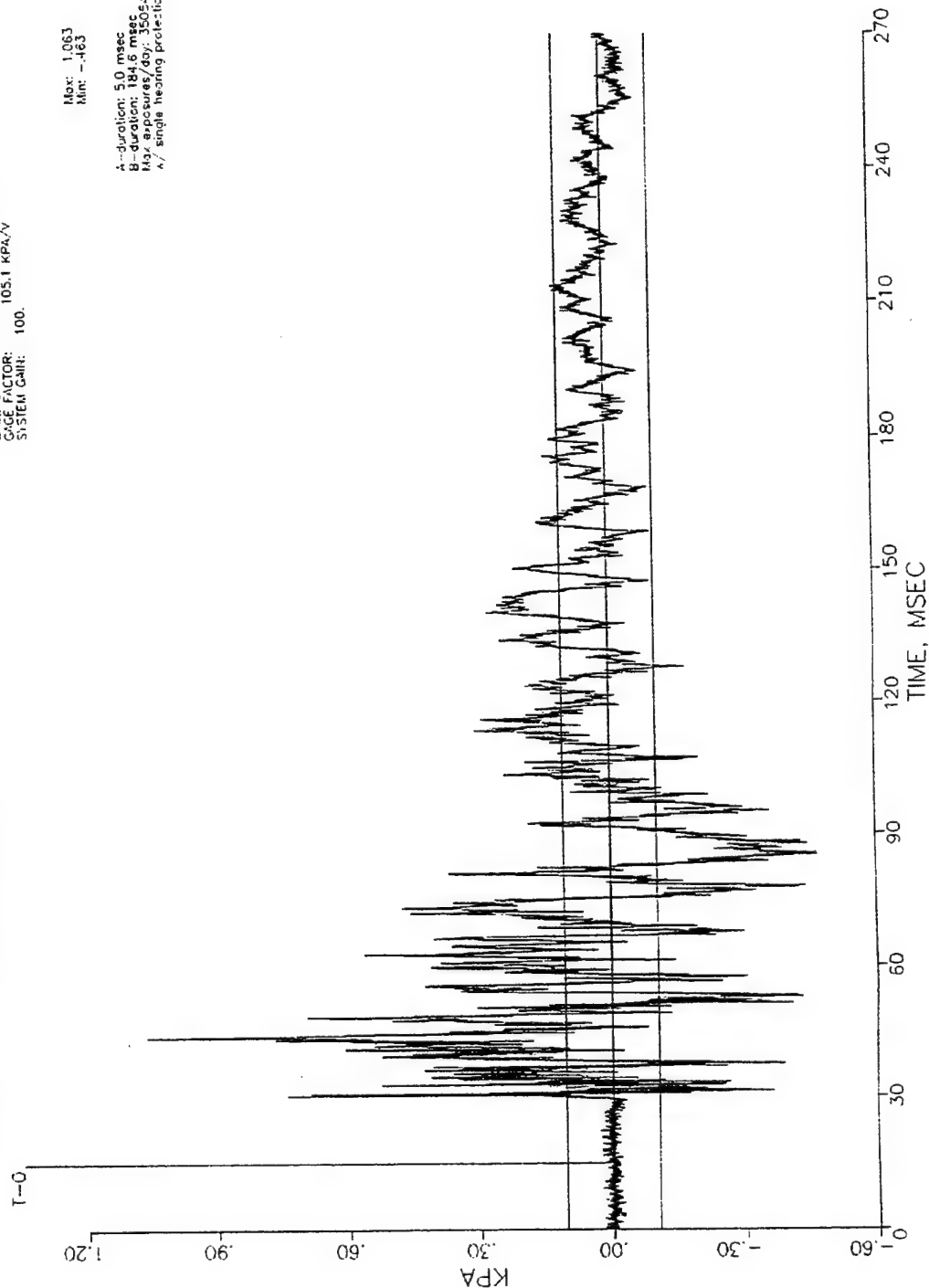


Figure B-45. Overpressure Plot for Shot 12 at the Driver Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 12 27 OCTOBER 1999
 CHANNEL 2 OVERPRESSURE, TURRET LEFT

LPF(A): 40000. Hz

GAGE ID.: PCB M114 /SU 4333
 GAGE FACTOR: 112.6 KPA/V
 SYSTEM GAIN: 100.



Figure B-46. Overpressure Plot for Shot 12 at the Turret Left Location

BRADLEY 40-MM GUN FIRE TEST
 ROUND 12 27 OCTOBER 1999
 CHANNEL 3 OVERPRESSURE, TURRET RIGHT

LPF(A): 40000. Hz

GAGE ID: PCB M114 /3110136
 GAGE FACTOR: 126.9 KPA/V
 SYSTEM GAIN: 150.

Max: 2.2
 Min: -2.1

A-duration: 3.0 msec
 B-duration: 117.0 msec
 Max exposures/day: 3709.
 w: single hearing protection

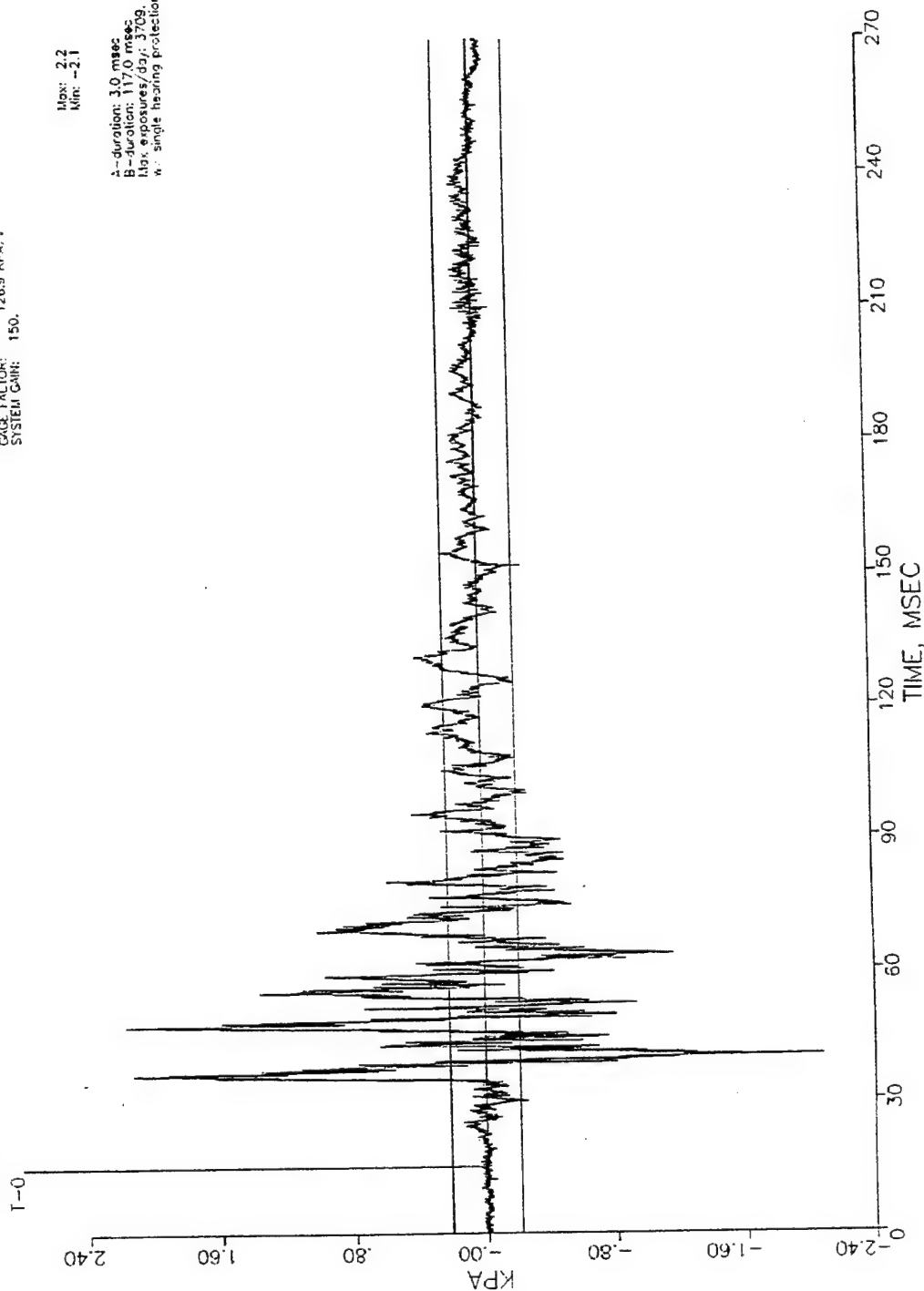


Figure B-47. Overpressure Plot for Shot 12 at the Turret Right Location

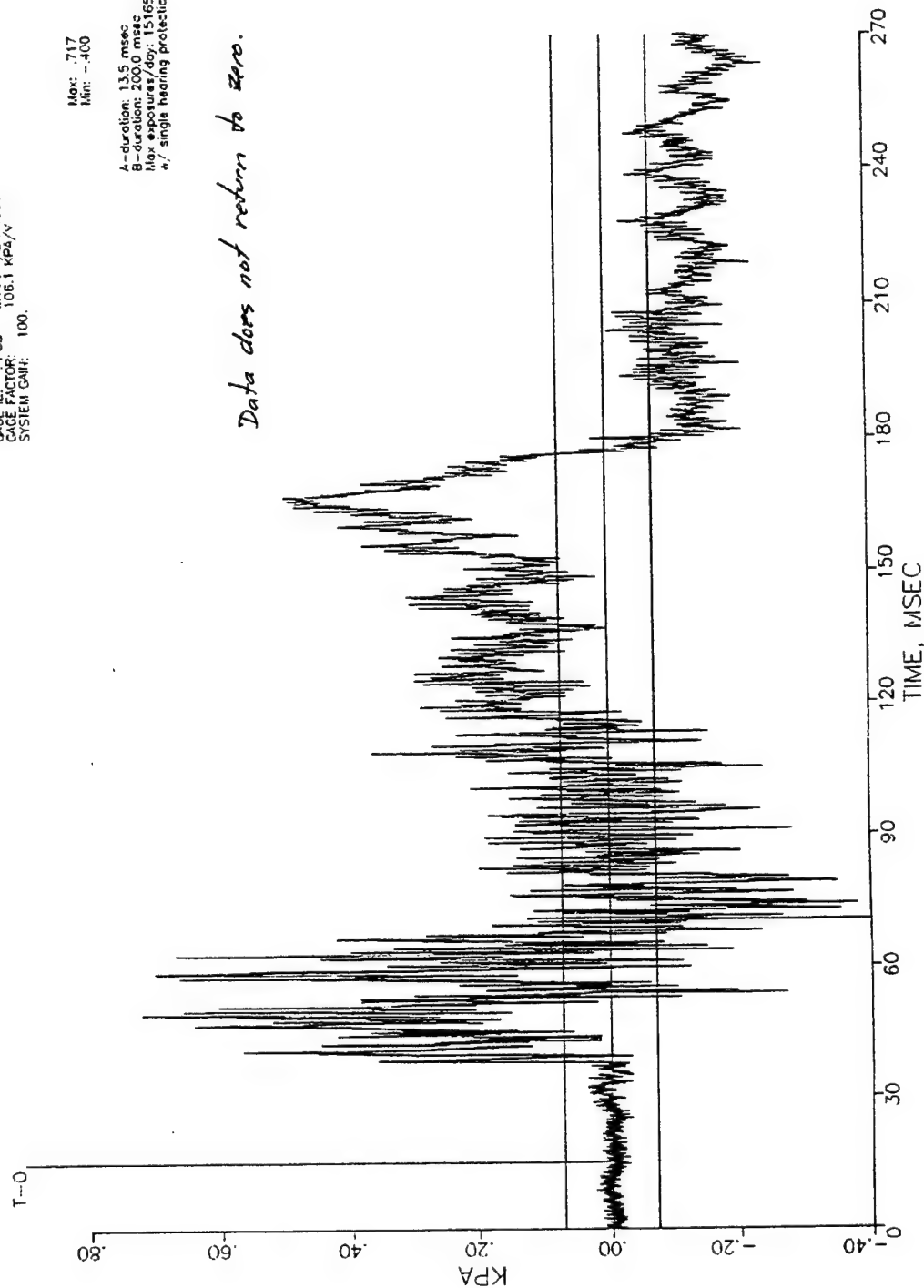
BRADLEY 40-LIM GUN FIRE TEST
 ROUND 12 27 OCTOBER 1999
 CHANNEL 4 OVERPRESSURE, REAR INSIDE HULL

LPF(A): 40000. Hz

GAGE ID: PCB M114 /SN 4989
 GAGE FACTOR: 106.1 KPa/V
 SYSTEM GAIN: 100.

Max: .717
 Min: -.400

A-duration: 13.5 msec
 B-duration: 200.0 msec
 Max exposures/day: 151655
 A: single hearing protection



Data does not return to zero.

Figure B-48. Overpressure Plot for Shot 12 at the Rear Crew Area Location

APPENDIX C
INDIVIDUAL SHOCK RESPONSE TIME PLOTS

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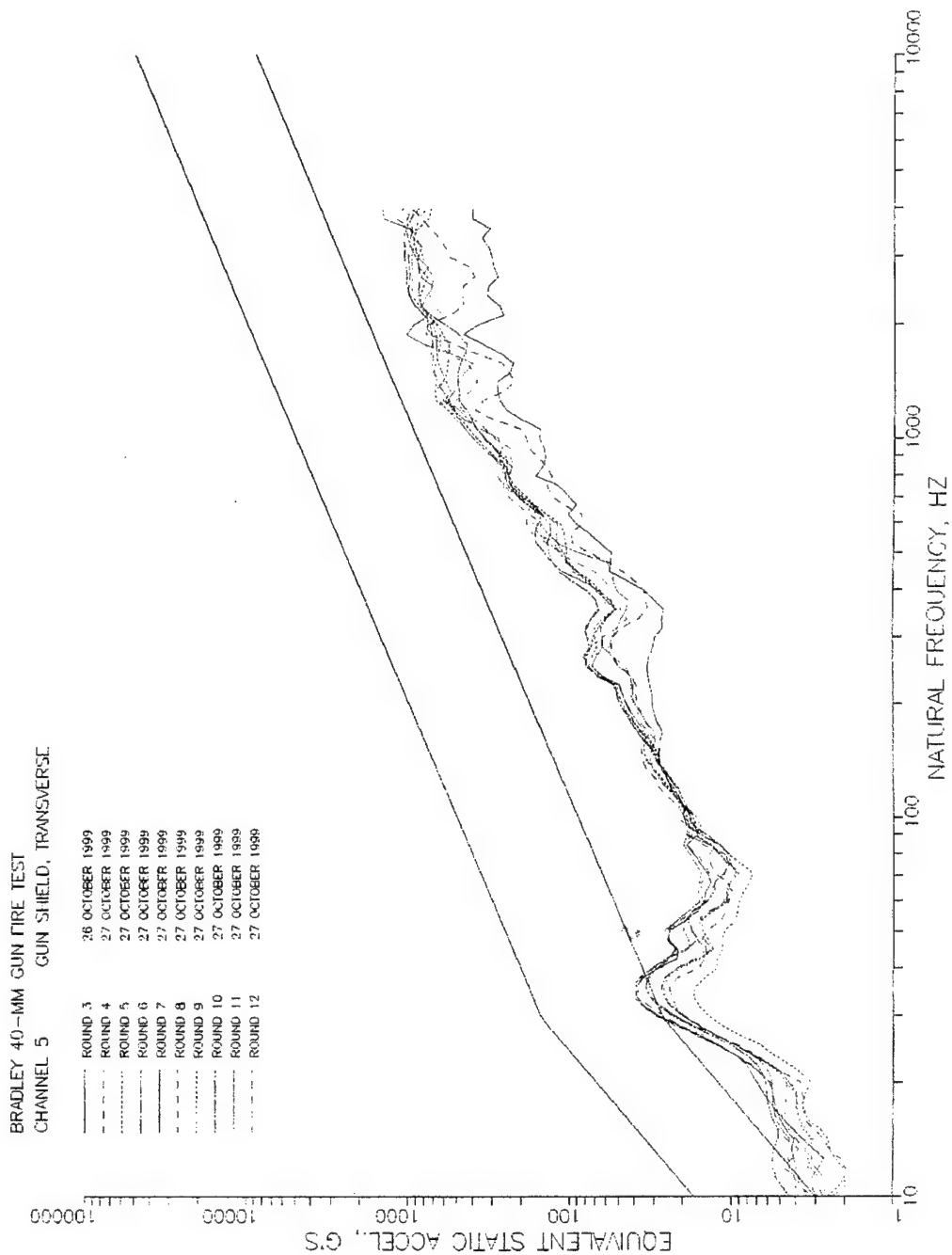


Figure C-1. Shock Response Time for all Shots at the Gun Shield Location (Transverse)

BRADLEY 40-MM GUN FIRE TEST
CHANNEL 6 GUN SHIELD, VERTICAL

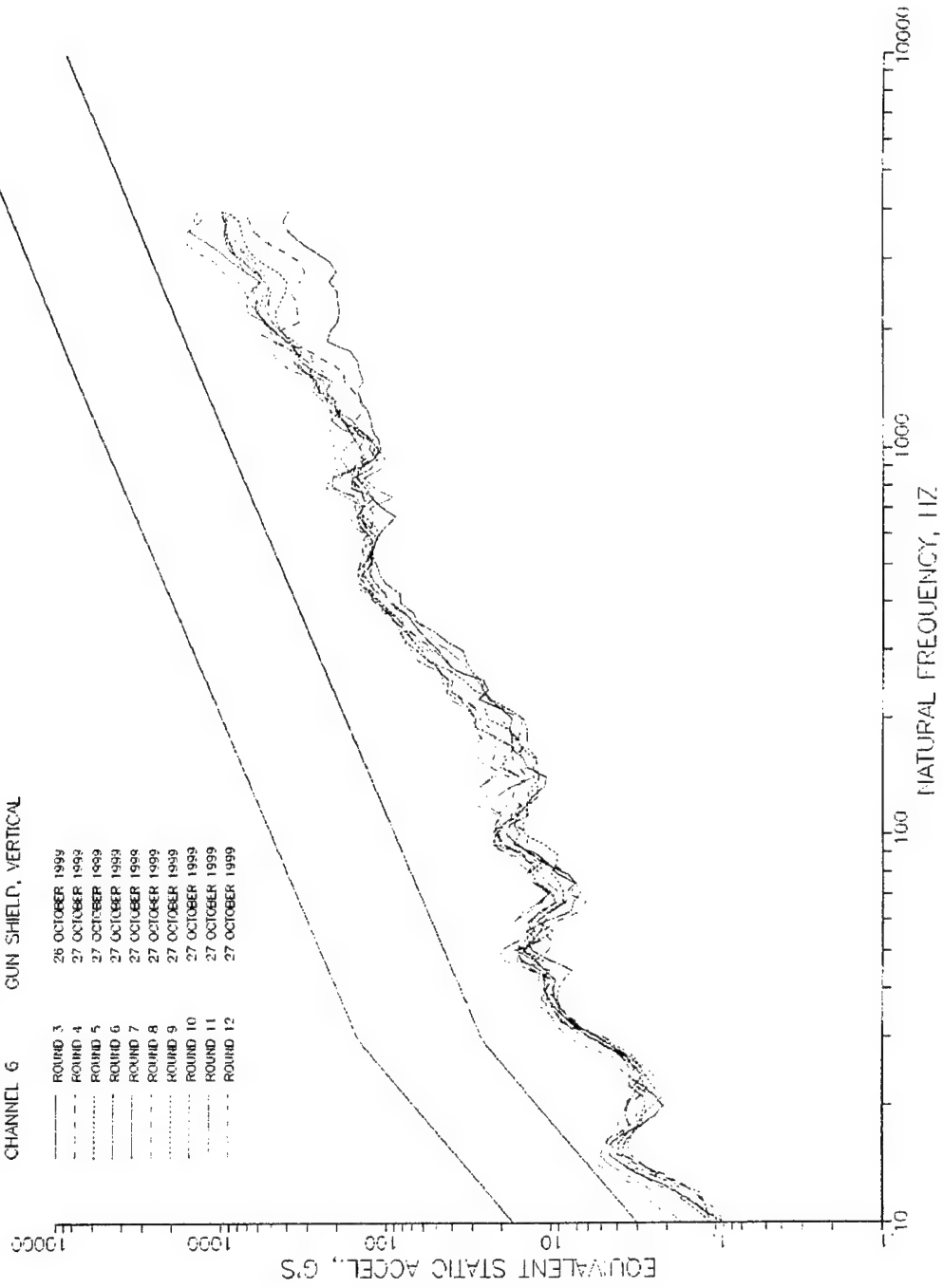


Figure C-2. Shock Response Time for all Shots at the Gun Shield Location (Vertical)

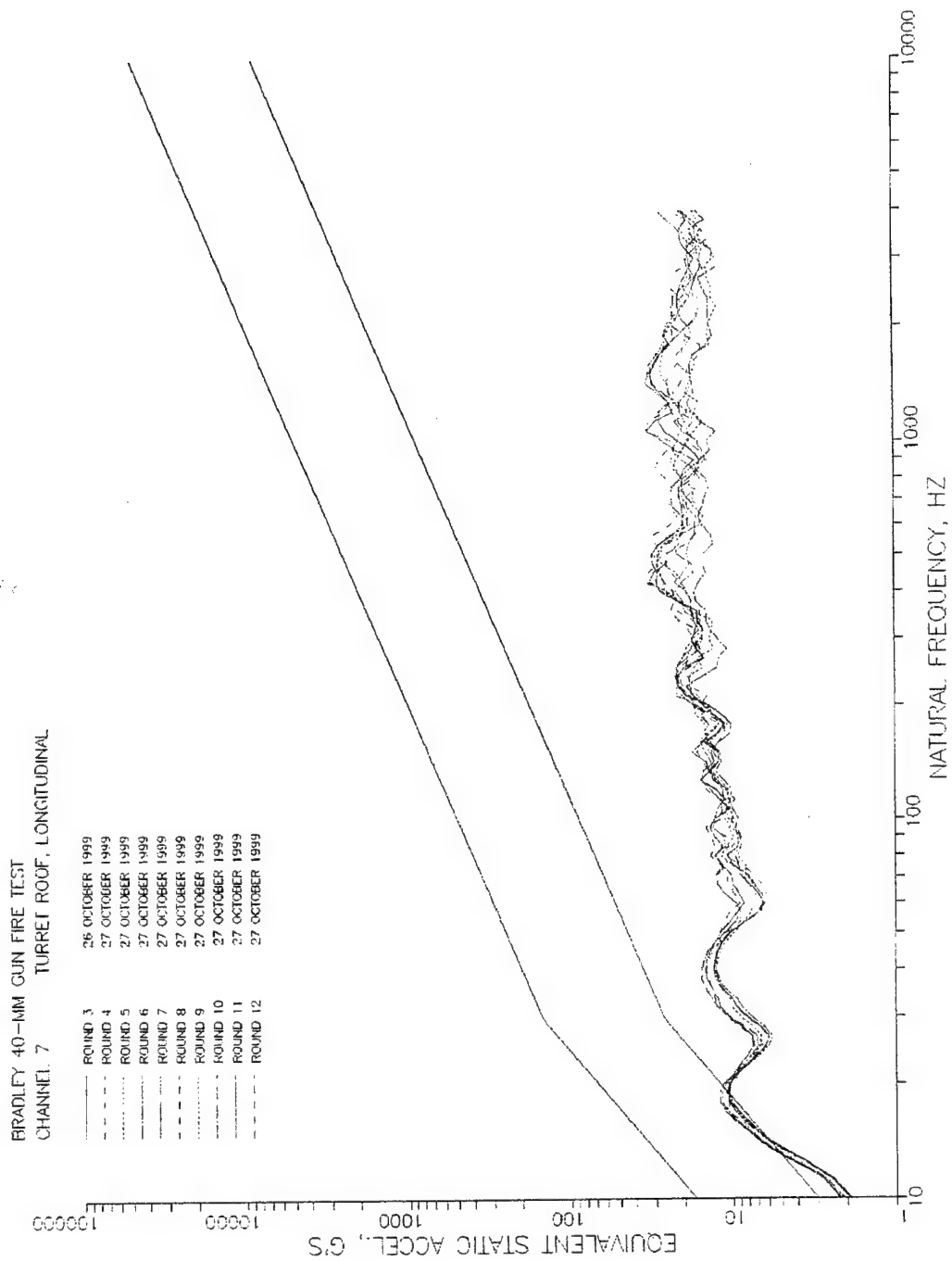


Figure C-3. Shock Response Time for all Shots at the Turret Roof Location (Longitudinal)

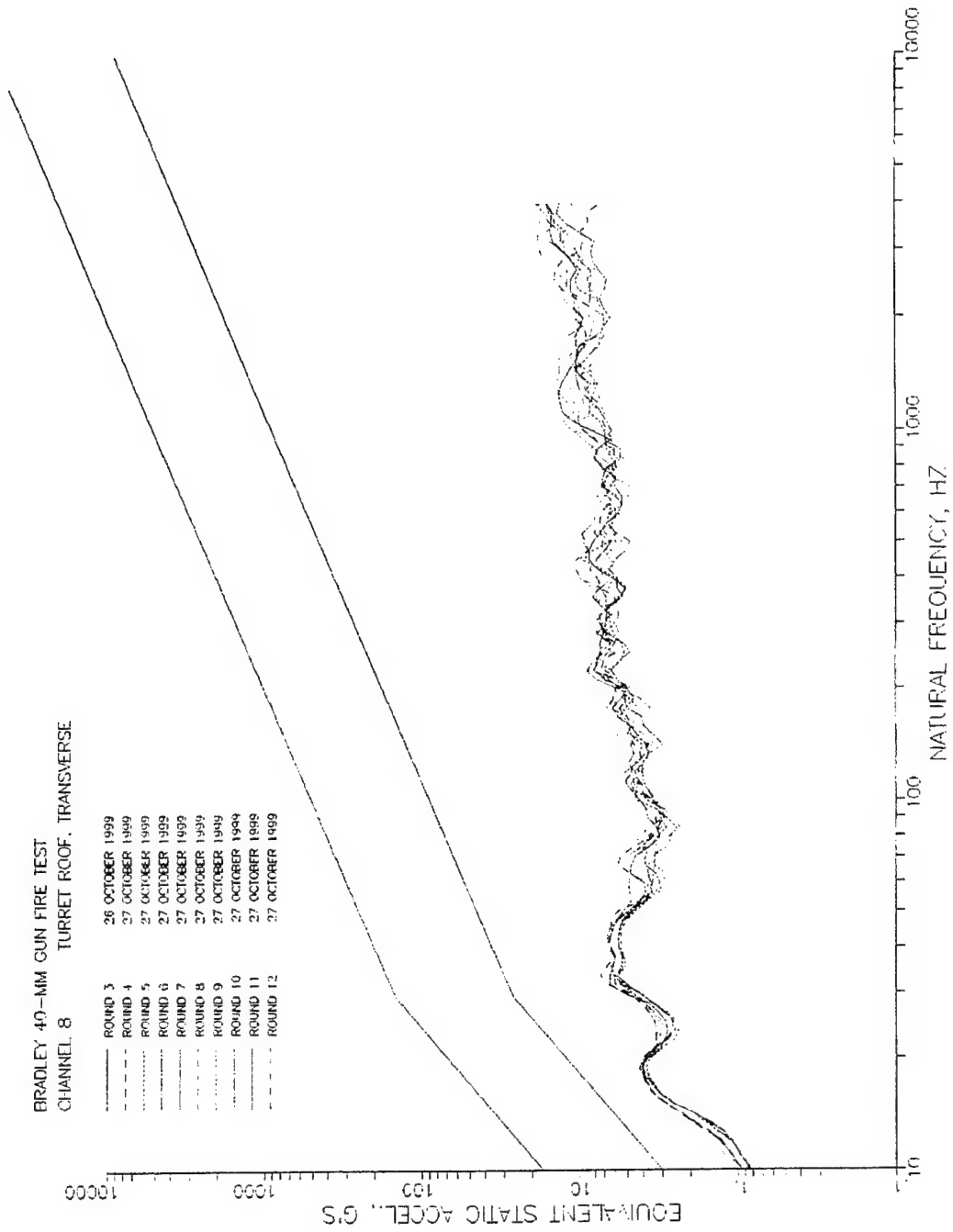


Figure C-4. Shock Response Time for all Shots at the Turret Roof Location (Transverse)

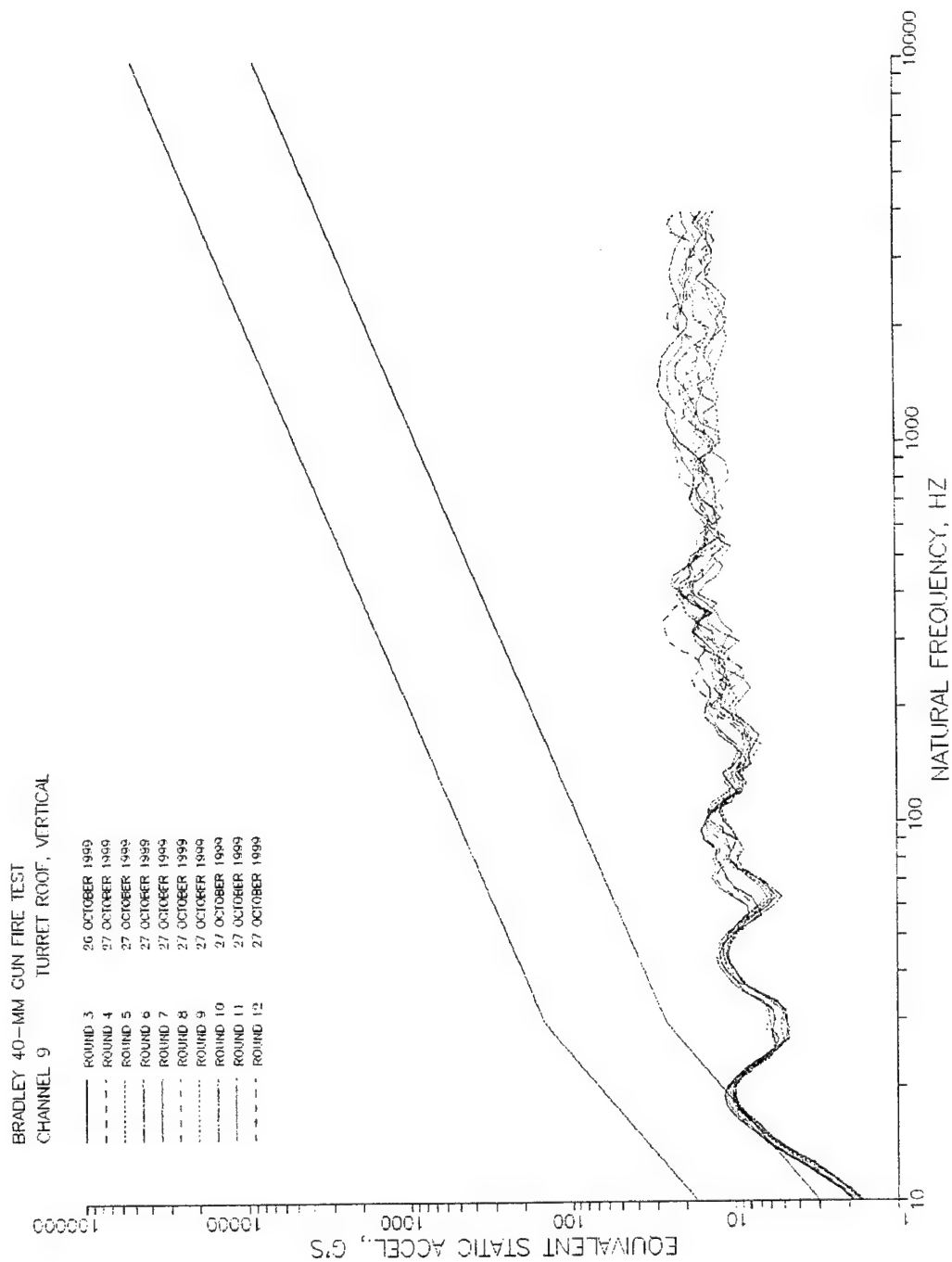


Figure C-5. Shock Response Time for all Shots at the Turret Roof Location (Vertical)

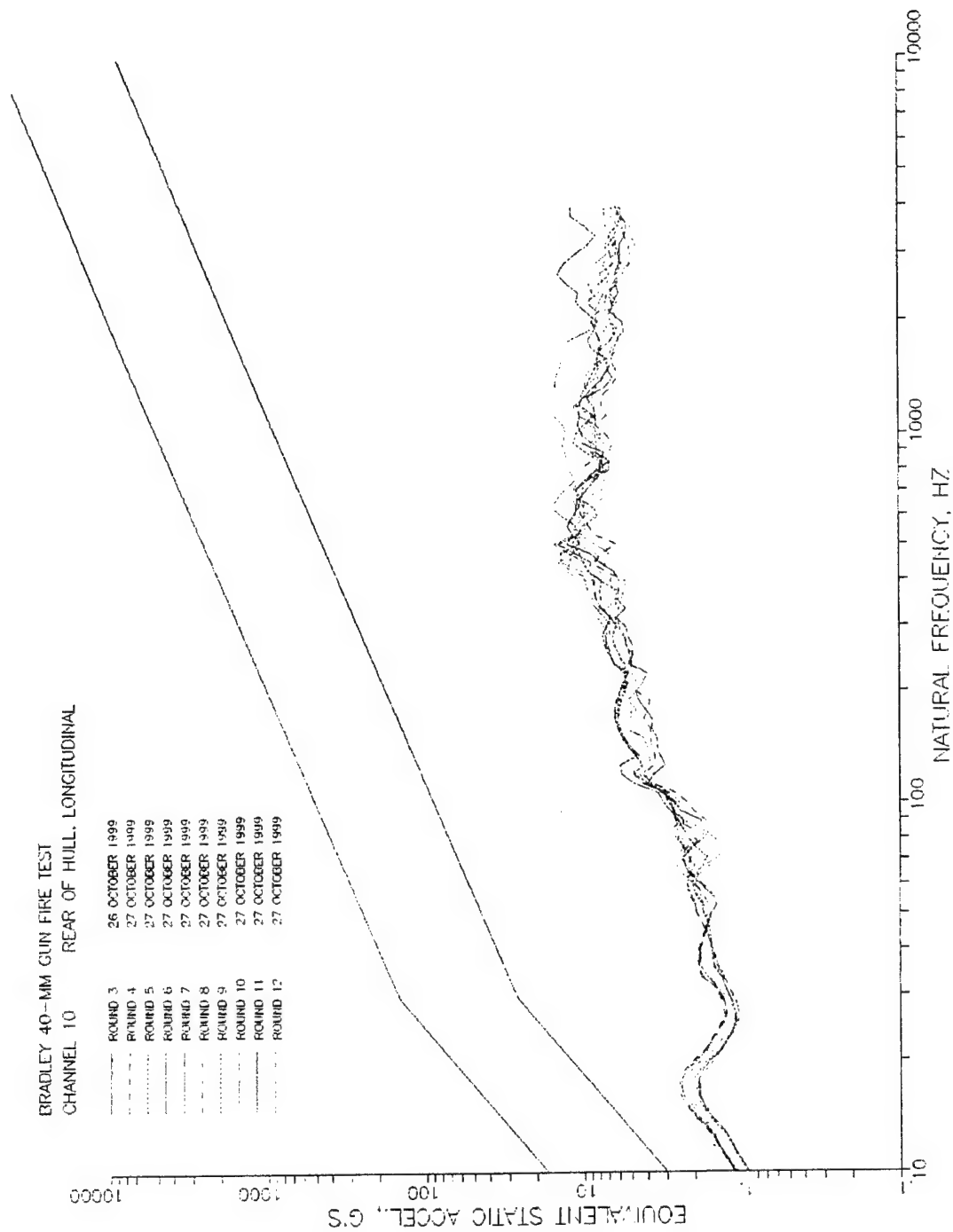


Figure C-6. Shock Response Time for all Shots at the Hull Rear Location (Longitudinal)

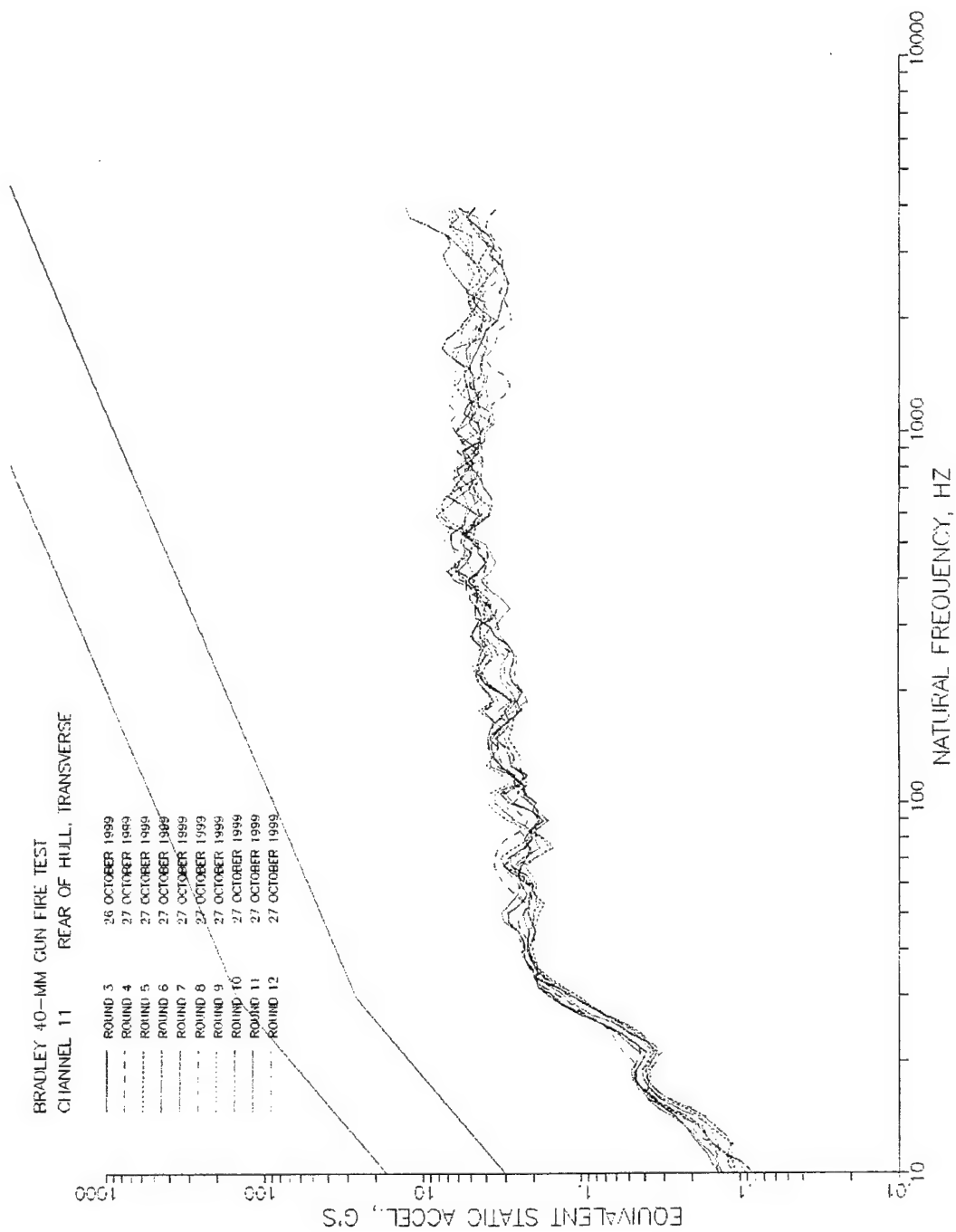


Figure C-7. Shock Response Time for all Shots at the Hull Rear Location (Transverse)

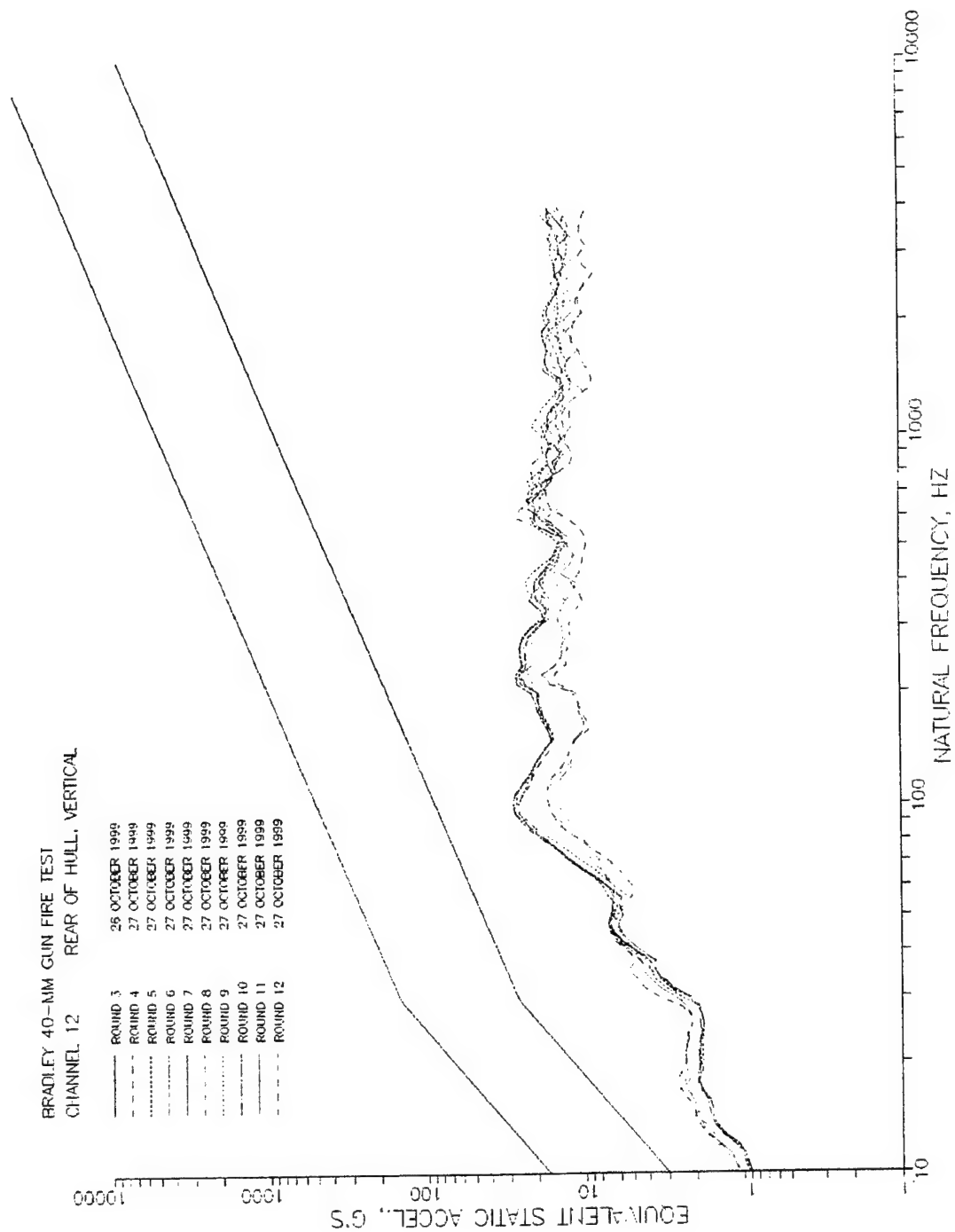


Figure C-8. Shock Response Time for all Shots at the Hull Rear Location (Vertical)

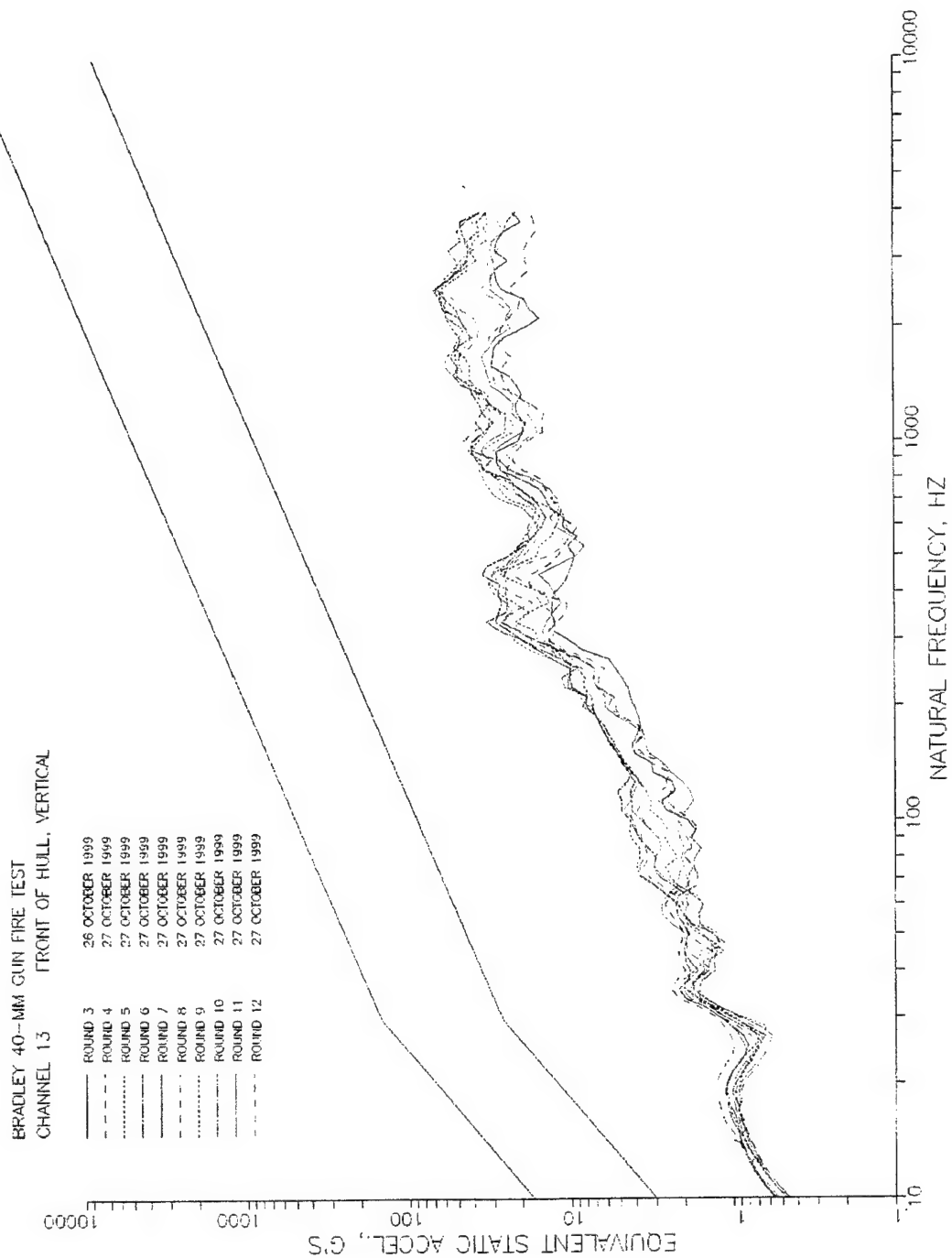


Figure C-9. Shock Response Time for all Shots at the Hull Front Location (Vertical)

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| 13. ABSTRACT (Maximum 200 words) The capability of off-the-shelf medium caliber ammunition has been advertised extensively. As the decision about the main armament for imminent medium caliber platforms approaches, more definitive independent analyses of the advertised systems are being conducted. To increase the current database, an evaluation of the 40-mm cased telescoped weapon system (CTWS) was coordinated between the U.S. Government and CTA International (CTAI), a French-United Kingdom company. The emphasis of this evaluation was the performance of the armor-piercing, fin-stabilized, discarding sabot (APFSDS) projectile. In addition, the pressures inside the Bradley fighting vehicle, where the CTWS was mounted, and shock measurements on the exterior of the vehicle were taken to estimate the effect of the weapon system on the vehicle and the crew. The evaluation of the terminal effects of the APFSDS against selected Senior National Representatives (SNR)-defined range targets is documented in a separate, classified version of the evaluation. The APFSDS ammunition performed as advertised, with a muzzle velocity of approximately 1640 m/s and a velocity decay of 0.12 m/s/m. These values give the 40-mm CTAI APFSDS a high velocity at the target for typical engagement distances. The measured shock to the vehicle and overpressures within the vehicle during firing all appear to be at acceptable levels for these initial tests. | | | | | |
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